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ORIGINAL ARTICLES

A DISCUSSION OF INFRA- AND SUPRAVERSION OCCLUSION*

Considering Facial Proportion as a Basis of Diagnosis Rather Than Molar or Incisor Occlusal Planes

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HISTORY

THE type of malocclusion which the subject conveys to the minds of orthodontists, though the terminology be inexact,† appears in our literature for the past fifty years.

In 1873 Charles Tombs of England recorded a case of open-bite. His diagnosis, though scantily stated, was that of supraversion of the second permanent molars, for the reason that he closed the open-bite by extraoral pressure on the chin. Facial length was, therefore, decreased by depressing the molars.

Smale and Colyer in their joint text, *Diseases and Injuries to the Teeth,* published in 1893, spoke of open-bite cases as follows: "Lack of anterior occlusion may be caused in several ways, by thumb, finger, lip or tongue-sucking, or may be due to want of development of the ascending ramus, and it might in some instances be due to a partial arrest of development of the intermaxillary bone."

Davenport in 1896 illustrated his method of raising molars and premolars to a higher plane of occlusion.

Available literature published since 1900 (which dates the beginning of modern orthodontia) typifies the preponderance of mechanical analysis which

*Read at the twenty-ninth annual meeting of the American Society of Orthodontists, Nashville, Tenn., April 8 to 11, 1930.

†As a clarification of our orthodontic terminology with respect to the conditions to be discussed, namely, supraversion and infraversion, I would offer the following two words as substitutes: hyperdysplasia for supraversion, and hypodysplasia for infraversion. These terms more exactly define the abnormalities I shall discuss.

orthodontia has employed in explaining the cause and effect of growth disharmonies. Hellman's work at the New York Museum of Natural History is a scientific contribution to a clearer conception of the vertical growth of the human face. His findings, derived from anthropometric measurements made upon skulls of different ages, substantiate my own observations in handling cases of deficient vertical height (infraversion) in the molar and premolar region. His several papers, dealing directly or indirectly with the influence of the teeth upon the vertical growth of the face, seem to prove my own approach to the problem of diagnosis.

FACIAL LENGTH AS BASIS OF DIAGNOSIS

Literature indicates that the orthodontic conception of open-bite and deep overbite cases was arrived at by comparing the occlusal planes of the anterior to the posterior group of teeth. This would be a sound basis for diagnosis were it possible to establish a norm of vertical height in either of the two groups. Fig. 1 illustrates a deep overbite (supraversion?) of the incisors. By comparing the occlusal plane of the incisor and canine group with the plane of the premolar and molar group, two conclusions of equal value may be reached. One may assume that the molar group is correct in vertical height. If so, the incisor group is excessive in vertical height (supraversion). Or, conversely, it would be equally correct to establish the incisor group as normal in height, and by comparing it to the molar group conclude that the latter was abnormally deficient in height, or in a state of infraversion.

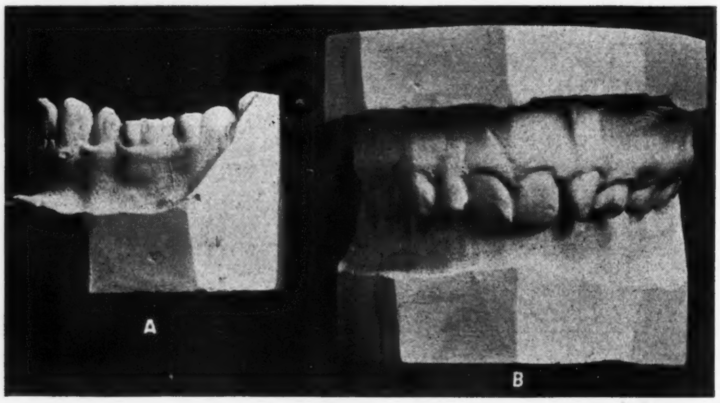


Fig. 1.

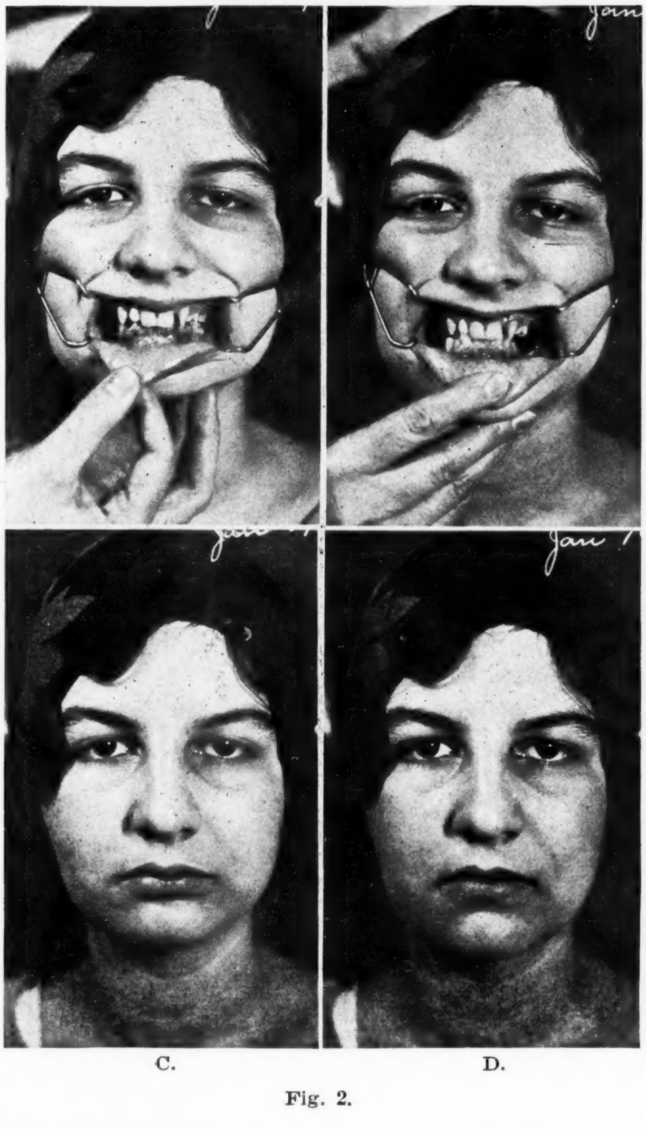
Such methods of diagnosis completely fail for lack of a norm as a basis of comparison. During the past fourteen years a study of facial height has been employed in cases presenting an open-bite or deep overbite of the incisors in the following manner:

Fig. 2 illustrates (same case as Fig. 1) a deep overbite of the incisors. With the posterior teeth in occlusal contact, facial proportions are studied. By raising the jaws apart (in this case about one-quarter of an inch), compare *B* and *D* to *A* and *C;* the facial length is increased and a comparison of facial balance is recorded. The increase in facial length shows a definite improvement; the case is unquestionably one of infraversion of molars and not supraversion

of the incisors. The diagnosis would, of course, determine the method of treatment.

Fig. 3 also illustrates a deep overbite of the incisors. So far as incisor relationship is concerned this case is almost identical with the previous one. But with the molars in occlusal contact, the facial balance in this case is normal. This deep overbite, therefore, should be diagnosed as a supraversion of the incisor teeth, or an extreme limitation of normal variability.

A. B.



C. D.

Fig. 2.

We have just demonstrated two cases, both presenting a deep overbite of the incisors. In the first case, Fig. 2, the deep overbite was due to a deficient height in the molar region. Facial length proved the correctness of such a conclusion.

In the second case (Fig. 3), even though the incisal overbite was parallel, the fundamental cause of the overbite was confined to the incisor region which in no way involved a disturbance of facial length.

Fig. 4 is the antithesis of the two previous cases. The same study of facial proportions is employed. Some orthodontists would likely diagnose this case as an infraversion of the incisors, but with the molars in occlusal contact, facial proportions clearly indicate an abnormal increase in facial length, and, consequently, the open-bite is due to an abnormal increase in the vertical height of the molars, rather than an infraversion of the incisors. To close this open-bite by moving the incisor group to functional occlusion would be the movement of

Fig. 3.

Fig. 4.

teeth from normal to abnormal positions. It, therefore, follows that the correct treatment would be a lowering of the molars in vertical height, thereby gaining a functional overbite of the incisor group and restoring facial balance to harmonious proportions.

Fig. 5 is another open-bite of the incisors. The incisor relationship in this case, as compared to the previous one, is strikingly similar, but with the molars in occlusal contact facial proportions are in balance. Therefore, our diagnosis would be infraversion of the upper group of incisors and canines.

These last two cases, though the antithesis of the first two, are analyzed by the same fundamental, that is, facial length.

This classification of infra- and supraversion being founded upon facial length seems logical. Of course there are variations to these classical types, but such are only details of fundamentals, and they should not be confusing in establishing a logical diagnosis. Briefly, the four divisions may be described as follows:

1. A deep overbite of the incisors caused by a deficiency in the vertical height of the molars and premolars: facial length abnormally short.

2. A deep overbite of the incisors caused by an excess vertical eruption of these teeth: facial length normal.

3. An open-bite of the incisors caused by an excess vertical height of the molars: facial length abnormally long.

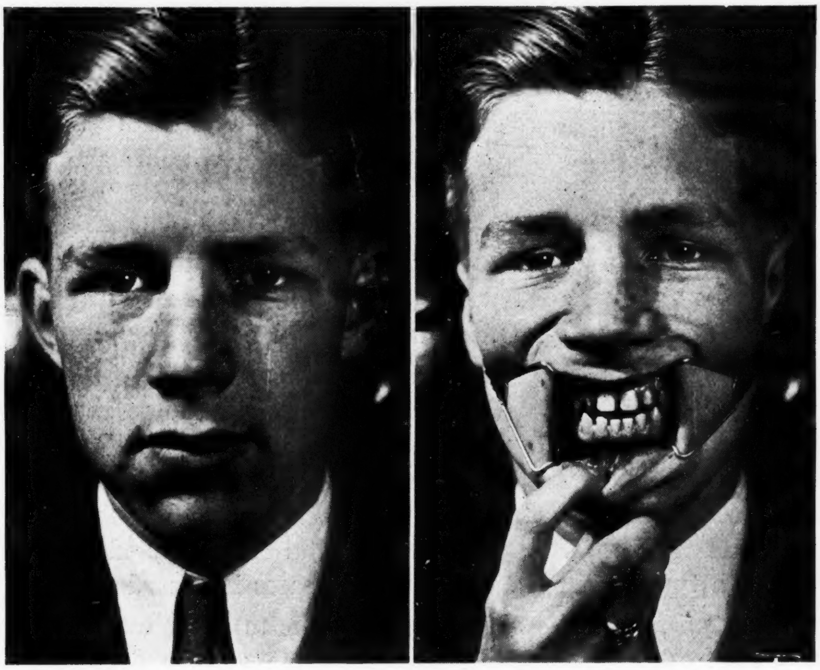


Fig. 5.

4. An open-bite of the incisors caused by an arrestment of vertical growth in this region: facial length normal.

A classification of variations of any anomaly is conducive to a more orderly method of diagnostic study. My experience in handling cases of infra- and supraversion, all based upon the above diagnostic study, has been most gratifying. (Slides of treated cases.)

METHODS OF HANDLING THE FOUR TYPES

In the type where the overbite of incisors is due to a deficient vertical height of the molars, no attempt is made to correct the condition in prepubescent cases. Such attempts in prepubescent cases have been largely unsatisfactory. These patients are put on the observation list and required to report every twelve months. If the patient does not become normal by the age of fourteen, and a great many do, assistance is attempted. My observation strongly points

to two conclusions in this type of malocclusion: that vertical deficient height in the molar and premolar region is purely an expression of retarded growth in this area and that an accelerated impetus often takes place at or about the age of puberty. The advent of the second permanent molars is also an added stimulus to vertical height. The greatest acceleration in the entire cycle of growth takes place at this age, and Hellman's findings practically substantiate my procedure in such cases. My most spectacular results have been accomplished upon children who demonstrated a marked increase in skeletal height. Now the question arises: would those children who demonstrated a spectacular result at the age of pubescence have made a complete recovery without orthodontic assistance? To prove this is, of course, impossible. Skeletal height increase seems, however, to be correlated with vertical dental height increase.

The second type, with a deep overbite of incisors involving a supraversion of this group of teeth (facial length normal), presents at least two avenues of approach. Some of these cases show a decided lingual inclination of the molars and premolars and when these teeth are tipped buccally to an upright position, the overbite of the incisors automatically becomes normal. Other cases present no other criticism save the overbite, and whether their positions represent a phase of normal variation or not, is then a debatable question. If no trauma to the gum tissues is present, my choice would be to let well enough alone. To depress the incisors is hazardous, even by the most skillful, as both pulp involvement and root resorption may be incited.

The third type, that is, an open-bite due to supraversion of molars producing an abnormal increase in facial length, has been up to the present uncorrectable in my hands. Extraoral pressure is the method indicated: a shortening of facial length is demanded. Some of these cases involve the lengthening of the ramus and a bending of the angle of the mandible. My observations and published reports from the Scottish Rite Hospital for Crippled Children seem pertinent in such types. A prognosis for these cases is hazardous.

The fourth type, open-bite of the incisors, due to an arrestment of vertical growth of these teeth (facial length normal) often gives a definite history of some such habit as thumb-sucking, etc. All such cases in young children should be observed and not treated. The great majority will completely recover without mechanical assistance in any form. Other cases of this type are accompanied by deficient arch width in canine and premolar region. Lateral development in this region has permitted the closure of the open-bite without any mechanical pressure being applied to the incisor group. Several of my cases in which the open-bite has been closed with orthodontic mechanism, have shown positive resorption of roots of these teeth. Whether these roots would have resorbed anyway, of course, cannot be proved. Evidence, however, points to the contrary.

ETIOLOGY

Unfortunately for the status of orthodontic conceptions, mechanical explanations of cause and effect predominated in the minds of those who gave an impetus to the advancement of our specialty. This is excusable for the reason that dental educational offerings made it so. We read dozens of treatises

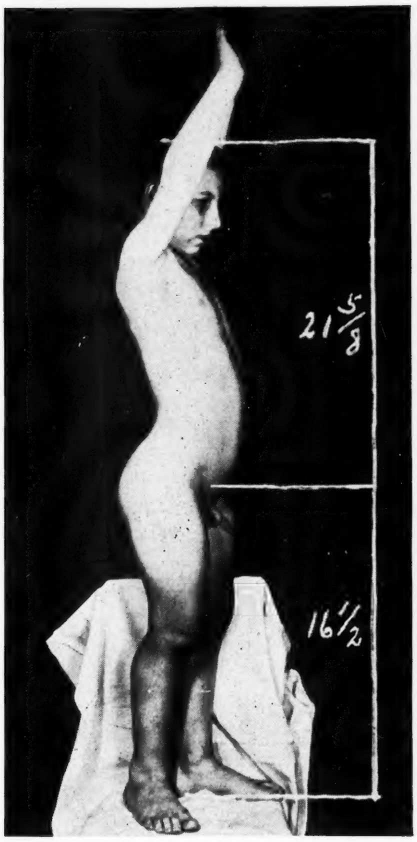


Fig. 6.—(Courtesy of Chas. E. Boynton, M.D.)

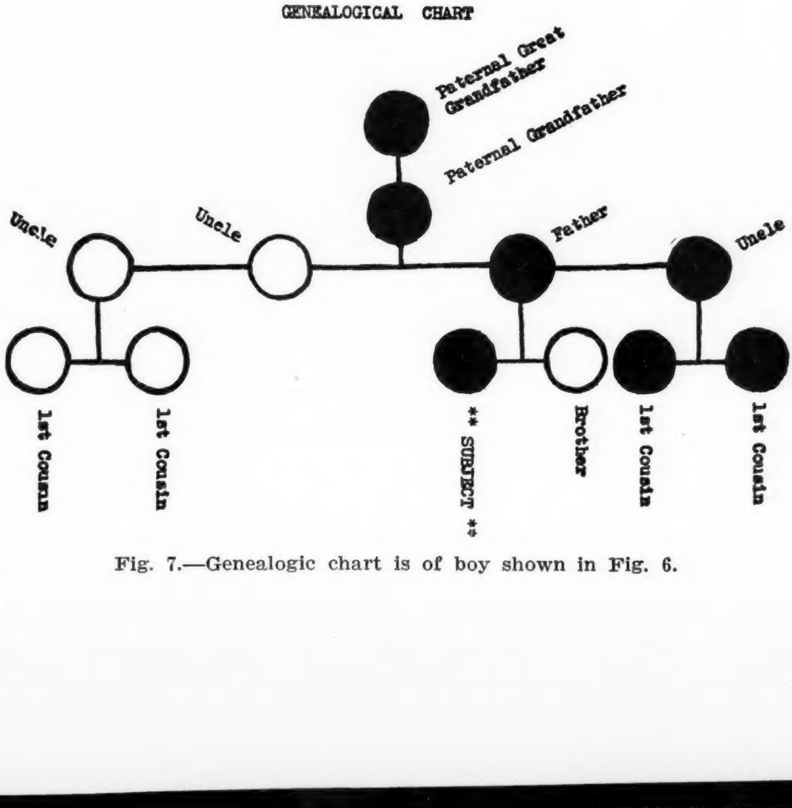


Fig. 7.—Genealogic chart is of boy shown in Fig. 6.

upon this subject, and mechanical explanations predominate. The biologic phase from the viewpoint of localized growth impulses is yet but a figure of speech. We are all familiar with such terms as thumb-sucking, tongue habits, pacifiers, lip habits, deficient muscle tone, etc., which explanations for cause and effect are good when observation proves their logic, but they have, until recently, been made a panacea for all orthodontic ills.

It was T. Wingate Todd who first showed an open-bite which he attributed to an arrestment of growth in a local area rather than a mechanical

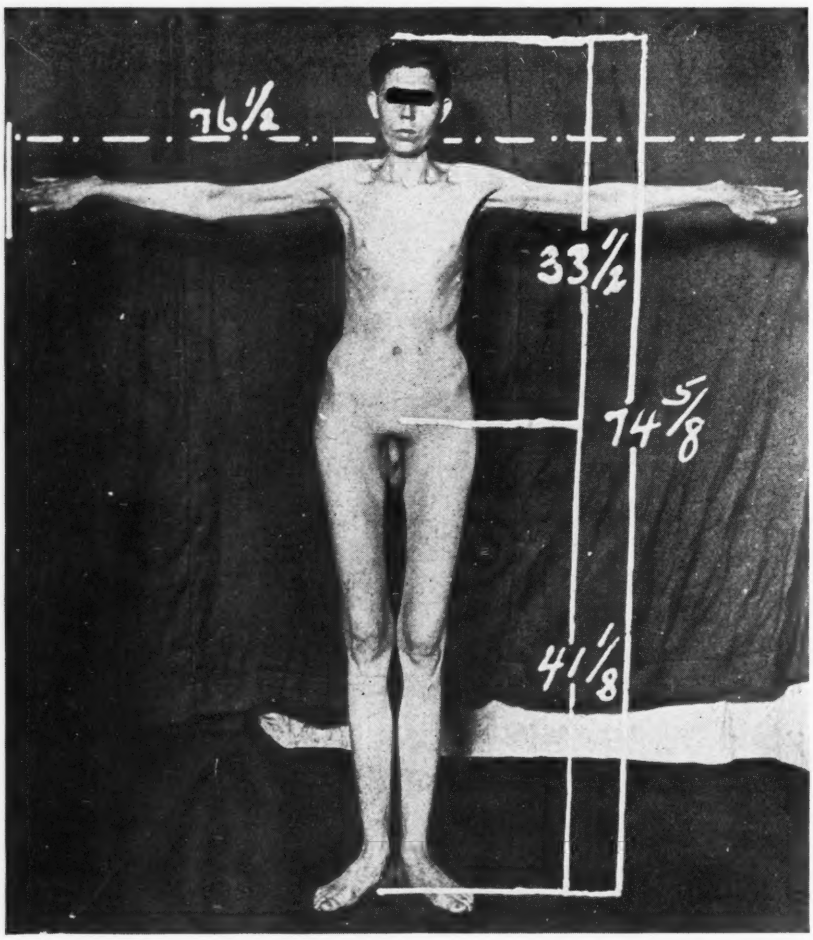


Fig. 8.-*A*.—Shows a disproportion in leg length as compared to torso to the extent of 7⅝ inches. (Courtesy of W. Nevin Adkins, M.D.)

influence. He called our attention to the fact that there actually existed accelerated growth areas in a given bone, and that retarded growth areas were also equally common in a given bone. This principle of bone growth has been overshadowed by our mechanical "law of bone growth." As an agent to growth, mechanical influences are certainly potent in effect. But to assign mechanical stimulation to the rôle of a panacean attribute is unscientific in the light of present knowledge. As an example of accelerated and retarded growth impulses, the following illustrations should be impressive. Figs. 6 and 7 illustrate the morphologic outline of body proportions of a case of achondro-

plasia. In this type of individual the long bones are retarded in growth. The hormones which direct growth in this area have failed in their assignment.

Fig. 8 *A* and *B* illustrates the opposite manifestation of hormonic influence. The long bones in these individuals are excessive in length compared to the average individual.

Mechanical stimulation had no part in designing the morphologic disharmonies of these types of people. Reverting to disharmonies in types of open and closed bites (infra- and supraversion) the etiology of such anomalies should

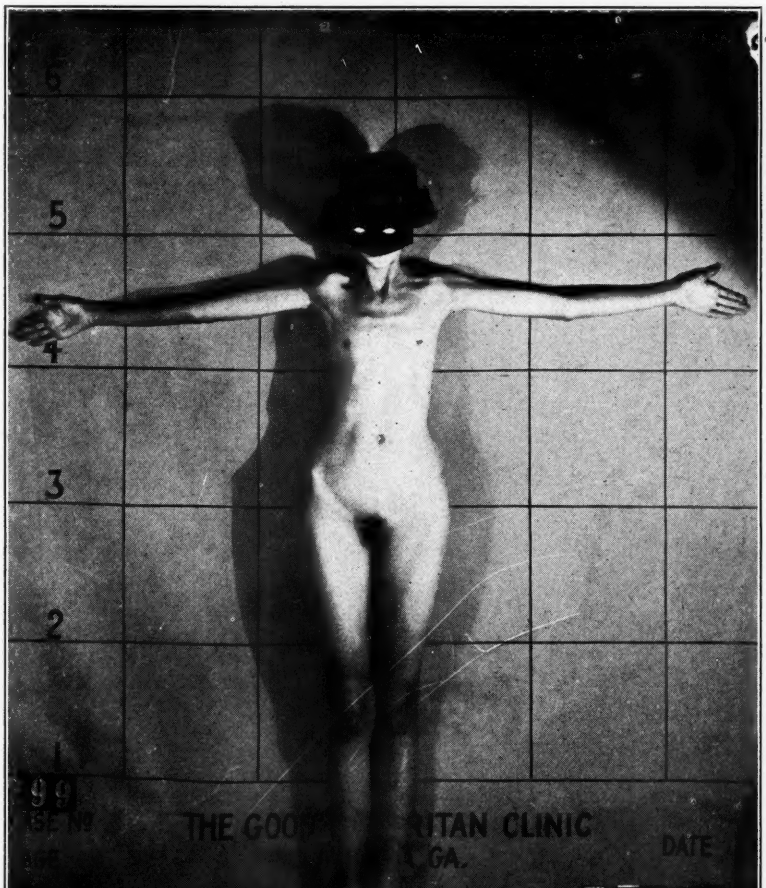


Fig. 8-*B*.—Is a case of approximately 9 inches in disproportion in favor of the long bones. (Courtesy of James J. Clark, M.D.)

be more correctly grouped into two classes. One group is local in origin, explained in mechanical terms; the other group is inherently biologic in the scope of analysis.

The mechanico-biologic explanation of anomalies presenting both open and closed bites has received voluminous attention, as indicated by the length of the list of references appended to this paper. One should be familiar with these mechanical hypotheses. They have a value and should be included in the mental armamentarium of diagnostic and etiologic acumen. The object, however, of this

discussion is to create a channel of thought which diverges from the ally-way of most orthodontic teachings. The etiologic problem seems more important than our attempt at offering a scheme of classification in diagnoses. As a study, it presents more confusion than diagnosis.

It appears logical to divide these anomalies into two divisions for study. One may not be an anomaly at all, but simply an expression of a physiologic

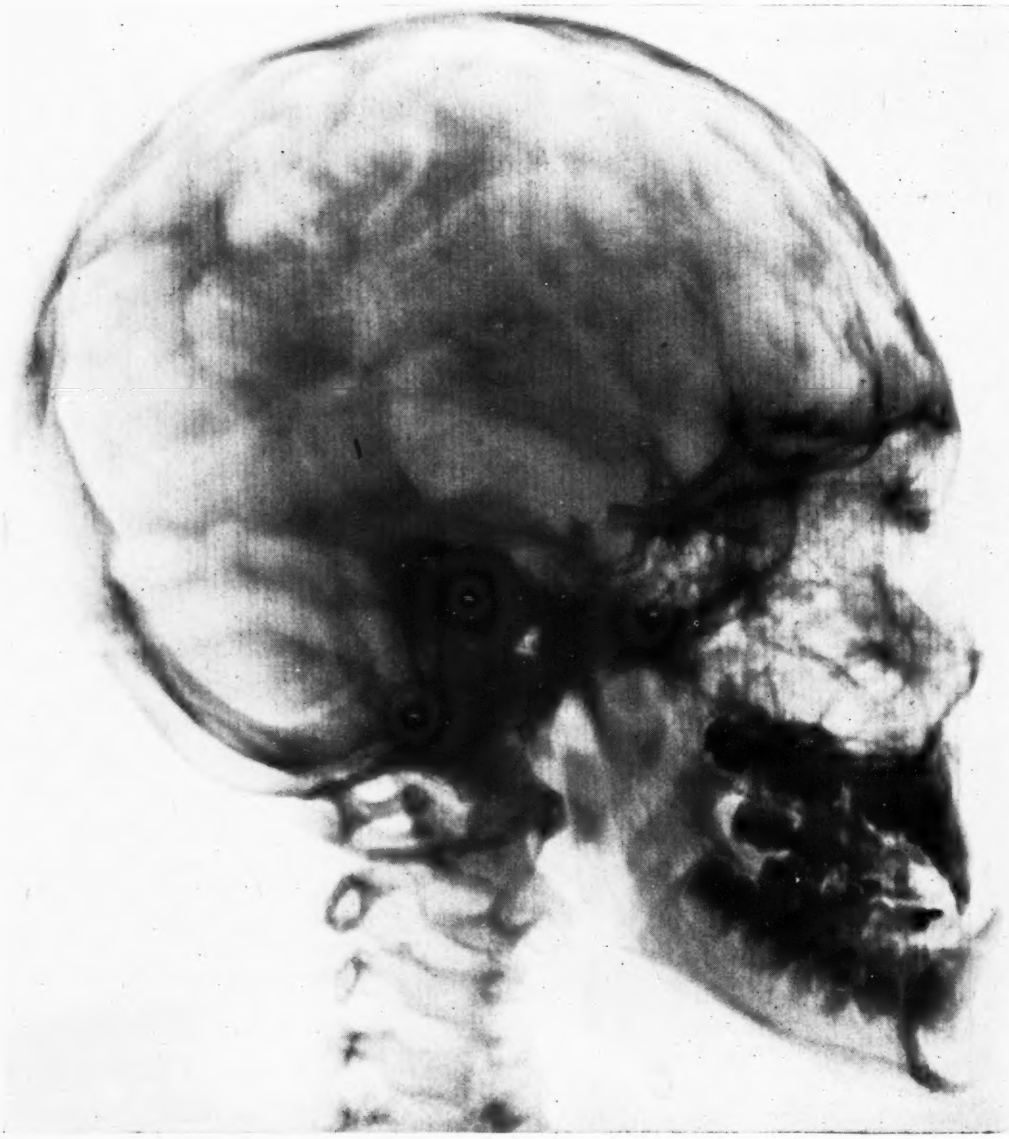


Fig. 9.—Illustrates the early closure of cranial sutures, as well as the sutures of the zygomatic arches. Skull growth and maxillary growth are definitely retarded. The mottled condition of the inner surface of the cranium is a condition resulting from pressure atrophy from the convolutions of the brain. Female, age eight years.

variability. Such conditions of tooth relationship, which appear as simple deviations from normal, often express a temporary stage in nature's complex scheme of growth progress. It follows, of course, that these cases assume normality without orthodontic assistance.

The second type for study are those cases which, though not normal from the viewpoint of the idealistic, yet are within the bounds of functional relationship. Who will determine their physiologic status?

At one stage in the evolution of orthodontic conception, roentgenographic surveys of the deciduous arches was employed as a guide for instituting a mechanical stimulation to increase arch width. If, for example, at the age of five, an x-ray picture of the incisor region showed a crowding of the permanent unerupted incisors, it was accepted as sufficient proof of the necessity of beginning arch expansion. This theory was based on the erroneous assumption that chronologic age was a criterion for physiologic manifestations. Further study developed that the crowded unerupted incisors were simply a physiologic stage of arch growth; it is but an expression of the normal variability of growth. Because the incisors were bunched at five years did not necessarily indicate that they would be crowded at eight or ten years.

Other illustrations of false concepts could be offered, but this is sufficient to approach the problem of infra- and supraversion at different chronologic ages.

Open-bite cases, due to a persistent habit (thumb-sucking, etc.), often become normal if the habit is broken during early childhood. Overbite cases in young children are frequently the expression of a stage in vertical height growth in the molar region. Many overbite cases in young children have become normal when given an opportunity to receive the influence of an accelerated vertical growth in the molar region. Of course, if the incisal edges of the anterior teeth produce a trauma upon the soft tissues, a mechanical interference should be immediately applied, but only sufficiently to relieve the trauma. Overbite cases without trauma to the soft tissues frequently express a periodic retardation in vertical molar and premolar growth. Actually, the overbite is but a physiologic variation.

As a magnified illustration of growth manifestations in the human head, your attention is called to a condition of bone-growth disharmony known as turricephalus (Fig. 9). All such cases have presented Class III types of malocclusion. As might be expected, they are not amenable to orthodontic therapy. The premature suture synostosis (early closure) is prevalent in both the cranial and upper facial bones. The mandible seems to be the only bone in the entire head which approaches normal growth dimensions. Aside from our discussion of retarded and accelerated growth impulses in different areas of the same bone (infra- and supraversion), this illustration is suggestive from two other angles. First, the inner surface of the cranium is mottled as a result of extreme pressure from the convolutions of the brain. If mechanical pressure "grows bone," why does not this skull grow? (Age eight years.) Second, how interesting it would be to diagnose this case by gnathostatic methods. Certainly turricephalic individuals, all having presented malocclusion (Class III), would demand a different scheme. In these people, from the magnified type down to the mildest form, the orbital plane is abnormally placed. It would be necessary to designate a point on the mandible from which we could predetermine the abnormal placement of the maxillae. But this is merely another incident proving the fallacy of any predetermining scheme which is

offered as a solution to nature's flexible plan of procedure. This statement is not made in the sense of decrying gnathostatic methods of study, but as another caution to those who might accept the orbital plane as a basis for diagnosis.

The author has purposely omitted a discussion of infra- and supraversion accompanying Class II and III cases. To cover the entire field would require a voluminous treatise, and time will not permit going into this phase of the subject.

My temperament is fundamentally that of an individual who believes that "all knowledge is relative and uncertain" and accepts nothing unless actual proof shows it to be true. My observations upon jaw and arch growth problems lead me to believe that a "rule by thumb" method of diagnosis followed by a "rule by thumb" method of treatment is but a sequence to a channel of training incompatible with scientific methods.

Nature rarely reveals her secrets cheaply. The multitude of avenues which she has to travel in approaching the ultimate product is so variable, through environmental and hereditary influences, as to make the task of understanding our fundamental problems seem insurmountable. But this should not be discouraging. Rather should it serve as an incentive for further and deeper investigations into those extrinsic and intrinsic growth impulses which actually exist but of which we know so little.

The physiologic status of an adolescent individual offers a field for investigation with a greater potential scientific value to orthodontia than all other accomplishments up to the present time. It seems strange, indeed, that our specialty has been so slow in grasping the significance of the law of variability of growth. It is even less complementary to our intelligence when we are compelled to admit that our analytical vision is confined to a local field for study. Correlative study of orthodontic cases is begging for admission to our field. A study of accelerative and retarded growth manifestations is inseparable from correlative study. The one will evoke the other. A reasonable comprehension of both will constitute the gateway to a genuine scientific advancement.

CONCLUSIONS

1. A knowledge of facial length is indispensable in diagnosing infra- and supraversion.

2. A diagnosis arrived at by comparing the occlusal plane of the incisor to the molar group or vice versa is valueless, as neither group can be established as normal.

3. Observation on many cases of young patients presenting mild types of the two conditions are conclusive in demonstrating that they frequently make a complete recovery without mechanical assistance.

4. The previous observation points to the correctness of the theory that some periods of retarded growth are but temporary physiologic manifestations in many cases.

DISCUSSION

Dr. A. LeRoy Johnson, New York City.—The selection of Dr. Howard for the discussion of infra- and supraocclusion has proved a very fortunate one. In characteristic manner he has faced the subject squarely, approaching it from the standpoint of the biologist; i.e., view-

ing infra- and supraocclusion as developmental anomalies due to a perturbation or irregular variation of growth forces. His paper is not an attempt to demonstrate the technic of the treatment of infra- and supraocclusion; it presents an attitude and method of approach to the problem of infra- and supraocclusion. It seems to me to be consistent with the facts presented by Dr. Mendel in his paper on "Nutrition and Growth."

The point of view presented is most encouraging. It cannot fail in the long run to produce results. It is certainly true that the traditional custom of explaining infra- and supraocclusion, as in fact most other abnormalities in occlusion, on the basis of mechanical principles alone, and distinguished from those chemical and vital, has helped very little in understanding the biological significance of malocclusion. The past has made very definite contributions. Of this there is no doubt. But we must not cling to ideas and methods in the face of facts that contradict them. As a true clinician, Dr. Howard has gone deeper into the problem than a mere attempt to explain it in terms of mechanics, because the results of treatment have made it evident to him that he should do so.

Although the essayist has emphasized the advantage of the consideration of facial length over the comparative levels of the teeth in the study of infra- and supraocclusion conditions, he has also made it very clear that this is not the only consideration in the treatment of these cases. He does not rule out the comparative levels of the occlusal surfaces of the teeth, as we certainly recognize the existence of an abnormality there. Facial length is utilized as one means of determining the peculiar nature of the individual case. As a study in physical anthropology, averages of facial length with their S. D. might conceivably be used as the criterion for the determination of variations in questions of occlusal level. But this is not to the same degree in orthodontics. Other phenomena must be taken into consideration: the possibilities and limitations imposed by the growth impulse inherent in the tissues, the influence of the endocrines and other basic factors of metabolism upon developmental processes.

From the very nature of the problem there can be no one criterion of normality. The area of normal variation is too great, and the physiologic interconnections are too complex to rest the recognition of an abnormality in occlusion on one structural variable alone. We cannot work even to as definite morphologic standards in the treatment of malocclusion as are used in the treatment of certain other parts of the body. That organs and processes vital to life are constant is one of the safe physiologic postulates of physiologic science. Parts not so important show great variability. Claude Bernard pointed out the constancy of the internal environment of man as compared with the external, and showed clearly the limitations of the statistical methods in dealing with the individual characters. Lawrence Henderson in discussing the "Problem of the Normal" called attention to the constancy of the vital organs and processes as compared with the teeth as an example of the less essential group of structures of man. He says, "If it is true that teeth and jaws vary pretty widely in man, the safest conclusion to draw is that they should vary. This is simple common sense in accord with the experience of physiologists." Search where you will among the works of recognized authorities on the nature of the human organism, and you will find in regard to the teeth that we are faced with a condition of great variability. And this should be borne in mind in the approach to any problem of occlusion.

That we may not do an injustice to the splendid work that Hellman is doing or misinterpret Howard's presentation we must consider carefully the rôle of statistics in medical science. Statistical studies describe a class of objects as a class; they show probability, never certainty. A surgeon may perform a certain operation and from the statistical summary of deaths and recoveries conclude that the mortality of his operation is two out of five. This, obviously, gives no certainty of the next operation. Will it be among the recoveries or deaths? There is a probability but never a certainty. So the averages of facial length cannot be taken as an absolute line of what is right; it indicates the general tendency of the group measured. The area of normal variation signified by the standard deviations is determined by the individuals of the particular group measured. It cannot define with definite certainty the limits of normal variation for all individuals. Statistical averages serve as a background against which the peculiar nature of the case can be seen. Therein lies

their value. Knowledge is relative. Without these statistical studies we have no basis upon which to build. An ideal concept unverified by facts derived from recorded observation has no place in Dr. Howard's concept. He asks you to get away from such ideas. He has called attention to the natural normal change with age in the degree of overbite and says that he makes no attempt to correct the deep overbite of incisors in prepubescent cases. He puts them on the observation list and finds as others have found that many of these cases correct themselves. This is one of the hopeful signs of today that a few men, and the number is growing, will observe and study cases of younger children before putting on appliances.

The concept of the physiologic phenomena of growth processes in osseous tissue has been warped by an overemphasis of the mechanical law of bone growth. The essayist says: "As an agent to growth mechanical influences are certainly potent in effect. But to assign mechanical stimulation to the rôle of a panacean attribute is unscientific in the light of present knowledge." Here the essayist calls attention to the fact that we do not know the effect of the force of our appliances upon the normal growth impulse of bone. We can modify the form of bone, and I grant you that in the modification of form growth processes are involved, but to cause growth in the sense that Dr. Mendel has defined it by the force exerted by the appliance is quite another thing. Because growth changes may be evident during or following orthodontic treatment does not necessarily mean that these changes are the result of "stimulation from appliances." It is a matter of common observation that growth occurs without the aid of appliances, and it is a matter of clinical experience that growth does not always occur when appliances are used. I think Dr. Howard has pointed the way to study infra- and supraocclusion. When we realize that there are very real definite limitations to development inherent in the tissues themselves, that an explanation of a condition to be accepted must be based on established scientific facts, and that there is much we do not know, then we shall progress.

Dr. Milo Hellman (New York City).—I feel under obligation to say something about this paper, because Dr. Howard and I have been in touch about this for some years. Before he went up to read the paper he handed me some letters. On opening them I found one which he wrote me March 16, 1926, bearing on the problem dealt with in his paper, and my answer to it. I will just read you a few lines of my answer.

"Your letter of the sixteenth of this month is of unusual interest. There is nothing that would give me more pleasure than to answer your very pertinent questions. Your questions are about the most intelligent that I have been asked by any orthodontist, but under the circumstances I am afraid I shall have to disappoint you.

"My work on this problem is not quite complete. It will require a great deal more time for study and work to finish all the detail that is necessary to be able to give you an adequate answer. I am just now in the midst of it. By the summer I hope to have it all in shape to satisfy you."

As far as I know now, I do not think that the work is finished as yet, but I am certain from what I have heard today that Dr. Howard has furnished the answer as far as it is furnishable.

I may also say a word with reference to the manner in which he presents his subject It reminds me of a little story which was told by a lady who had just returned from Italy. She said that while there she happened to go into a moving picture house one evening, and to her surprise she noticed Mussolini come in and sit in front of her. The theater was dark and he was incognito. Soon after the main picture, the news reel was thrown on the screen, and his picture appeared. To her surprise she saw the whole crowd jump to its feet, applaud and yell, "Hurrah!" She was watching him and noticed that he was rather baffled. He did not know whether to stand up and be recognized or to sit still and be criticized. After the applause subsided and everybody sat down, an old lady next to him said, "Signor, this is how we all feel about it, but it is much safer to stand up."

The orthodontists as a general rule are too prone to stand up for anything that is popular, for fear that they may be criticized for not being abreast of the times. Dr. Howard not only has shown the courage of his convictions but also has produced a well-formulated method by which the problem he dealt with can at least be intelligently approached.

Dr. A. H. Ketcham (Denver, Colo.).—In discussing this brilliant paper I think I should speak of one point that has not been mentioned, namely, the depression of teeth which have been built up to open the bite. Dr. Norris C. Leonard of Baltimore has reported in a paper published in the INTERNATIONAL JOURNAL OF ORTHODONTIA, ORAL SURGERY AND RADIOGRAPHY, September, 1929, that in the treatment of several open-bite cases he has placed overlays upon the molars, thus opening the bite to a still greater degree. In the cases thus treated in from six months' to one year's time the molars apparently have become depressed and the face has become shortened. Upon the removal of the overlays from the molars the maxillary and mandibular anterior teeth were found to be together; then treatment of the malpositions of the anterior teeth could be completed.

I am reporting this so that you may read the paper. It may afford a ray of hope in the treatment of these cases.

Dr. L. H. Wirt (South Bend, Ind.).—I have an observation to make upon which I should like some enlightenment. Perhaps Dr. Howard can bring it out.

In these cases of excessive overbite, such as he showed, where there is infraversion in the posterior region, I wonder whether we do not have to deal sometimes with the fact that there are occlusive forces which normally are distributed over the whole arch, and we find a great many children in whom several of the deciduous molars were for some reason extracted before their normal time of loss, permitting the distribution of all the masticating forces over only a few of the remaining teeth. This, in my judgment, is working in the same direction as the application of the excessive masticatory force by the use of overlays, such as Dr. Ketcham referred to, and which we all use in another way whenever we use the bite plane for opening those bites. I wonder whether one of those conditions does not come about oftentimes by the distribution of the masticatory force in the wrong way by the extraction of teeth.

Working on that theory, I have had fairly good results by taking that pressure off the back teeth and permitting them to grow up to normal height. Then, as the other molars would come along, that would also stimulate further growth.

I also observed, in a study I made a few years ago of some smaller children, that we can find the onset of this condition in the very young. Many cases of children two and three years of age present this excessive overbite. We can sometimes determine that it is lack of growth in the back part of the mouth, and in other cases it seems to be an extra growth in the front part. I should like to have Dr. Howard's observation on those points.

Dr. Howard.—The schedule of today's session is now one and one-half hours late, therefore, I am waiving a rejoiner to my discussors.

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STUDIES ON APICAL ABSORPTION OF PERMANENT TEETH*

PART II

By John Albert Marshall, D.D.S., Ph.D., San Francisco, Calif.

BONE and the epithelial structures, as skin and mucous membrane, are the two tissues in the body which regenerate easiest from injury. When a comparison is made with cut muscle or tendon, the repair takes place with metaplasia. The specialized muscle cells are replaced largely by a fibrous connective tissue which differs histologically and physiologically from the normal muscle. In respect to mechanical trauma of both soft and hard tissues there is an added difference in the extent of the reaction in skin, muscle, cartilage and bone. A fracture, for example, may have associated with it a slight or a great amount of contusion of soft tissues. Furthermore, continuous pressure on soft tissue gives rise to a very different pathologic picture from that seen with bone or teeth. But the lesions following pressure trauma are not characteristic for only this type of injury, for the various forms of osteitis, whether of infectious or metabolic origin, present certain similarities. It has been frequently observed that impacted teeth produce pressure so prolonged that absorption of adjacent teeth and bone follows. Another cause contributing to rarefying osteitis is a long continued chronic apical infection. It usually gives rise to a similar reaction in which the roots of teeth may be absorbed laterally or apically or both.

The extent to which these processes may develop has been described and illustrated in a former paper,[1] but the histopathologic picture is not essentially different in man and monkey. In both instances it has been observed that the invasion into dentine by pathologic peridental membrane follows in cases where the lesion has been relatively of long standing. However, the absorption of the hard structures and the apposition of new tissue are many times nearly simultaneous processes, and are practically identical with local tissue reactions found in the experimental animals. In Fig. 1 is shown a longitudinal section between the mandibular incisors of one of the animals in which a large abscess cavity had developed. Here again the loss of tooth structure is observed to be a process similar to that discussed in connection with abscessed human teeth (Fig. 2).

The exfoliation of the deciduous teeth is the typical example of resorption associated with normal growth.[2] In fact the well-known histologic picture and the clinical manifestations constitute the basis for the study of the bone pathology associated with trauma of either infective or mechanical origin.

That both pulp and peridental membrane are concerned in this resorptive process is well known, but the manner in which the pulp functions and its

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relation to the fibrils contained in the dentinal tubules have not been demonstrated. The sections so far studied in this research, indicate that such a relation clearly exists and that activity goes on within the dentinal tubules during the period of active root resorption. The proof of this statement is in the fact that the dentinal fibrils are larger than those found in deciduous teeth in which no active root resorption is going on.

In Fig. 3 are demonstrated the beginning stages of normal root resorption in a mandibular deciduous canine. The activity in the peridental membrane

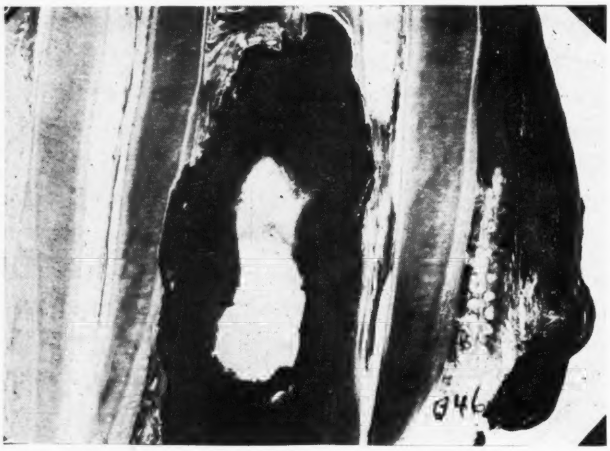

Fig. 1.—Abscess between mandibular central incisors.

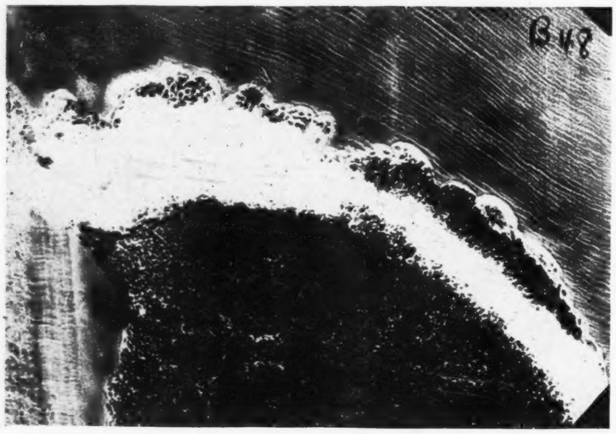

Fig. 2.—Absorption of cementum and dentine resulting from abscess.

is very distinctly shown. It will also be noted that a portion of the dentine on the distal aspect of the root presents the characteristic eroded line where the peridental membrane has encroached upon it. The cementum in this area is resorbed, and in its place is the hyperemic and slightly hyperplastic peridental membrane.

Fig. 4 illustrates a section where active resorption is taking place. Its magnification, 700 diameters, indicates the extent to which the dentine is being torn down. The fibrils are somewhat larger than those observed in areas where no resorption is going on. Furthermore, they are more closely spaced and

show greater numbers of interlocking strands. The significance of these differences will be discussed later.

The dissimilarities observed in the fibrils of deciduous teeth undergoing resorption as contrasted to those in which this process is not occurring, are sufficient to warrant the distinction mentioned in the first paper. This was to the effect that resorption be taken to refer to the physiologic and anatomic expression of growth and hence to the normal loss of radicular dentine in

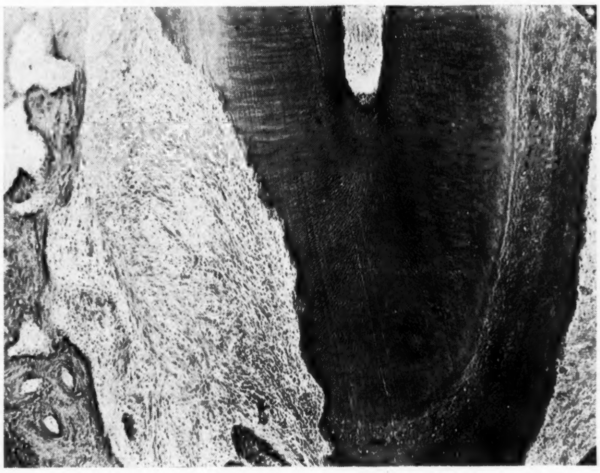

Fig. 3.—Early stage in normal resorption of deciduous mandibular canine.

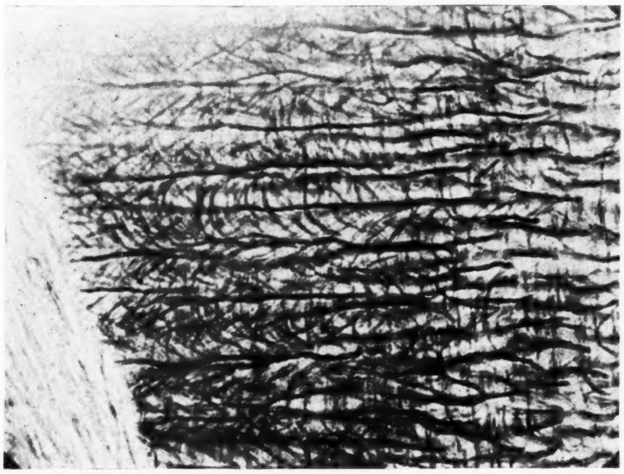

Fig. 4.—Active normal resorption of deciduous canine root. (×700, Schmorl's stain.)

deciduous teeth. But absorption, on account of the different pulp reaction, may be understood to mean a pathologic loss of tooth structure.

The bone and tooth root absorption described by Ketcham[3] and which has been demonstrated in laboratory experiments, has been found to occur also about the roots of permanent teeth which have never been treated orthodontically and, furthermore, which have apparently vital pulps. But it has not been proved that these pulps were entirely normal even though they responded to the usual clinical signs of vitality. There is a possibility that a long continued chronic inflammatory reaction is partly responsible for the shortening of the

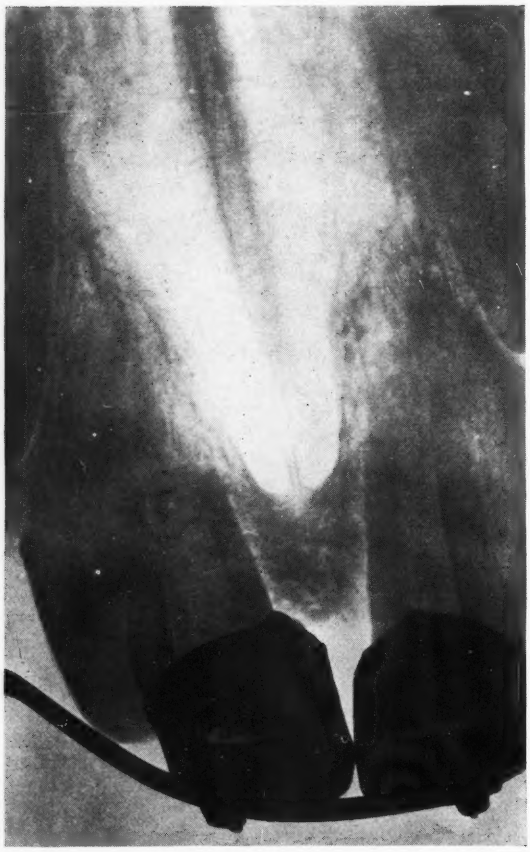

Fig. 5.—Enlargement from roentgenogram of animal No. 2, taken December 14, 1928.

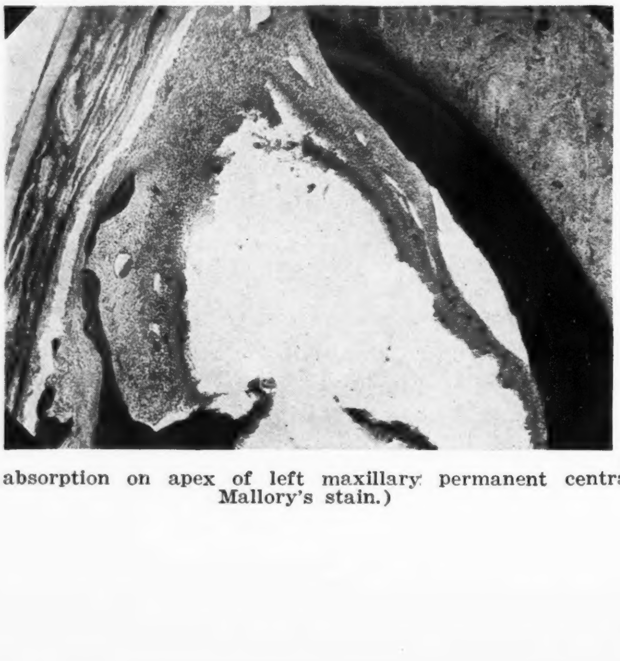

Fig. 6.—Pressure absorption on apex of left maxillary permanent central incisor. (×25, Mallory's stain.)

roots and the similtaneous calcification in the alveolus. In only a few cases has there been observed in our laboratory any evidence that soft tissue rather than bone has filled in the absorbed area.

These various aspects have been pointed out in detail on several former occasions[4, 5] and will be reviewed here only briefly. No discussion will be given for the moment to the results of other workers in this same field. Instead, it is proposed to describe certain developments in this present research.

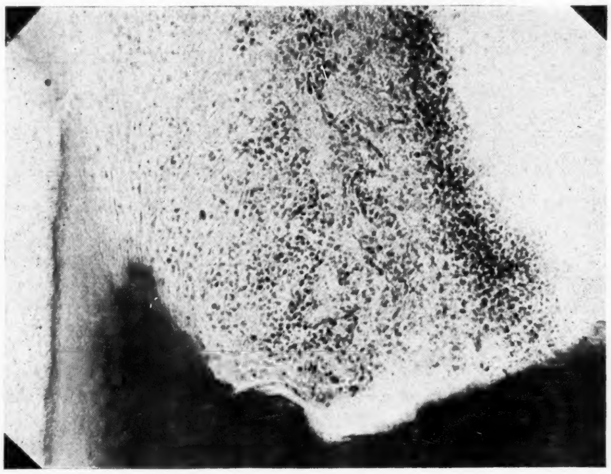

Fig. 7.—The characteristic ragged apical border of an absorbed area. Hematoxylin and eosin stain.

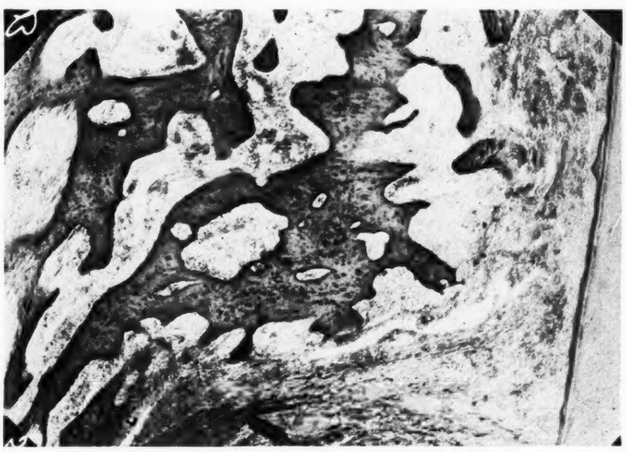

Fig. 8.—The bone and soft tissues have been pulled down toward the incisal as a result of extrusive movement of right maxillary permanent central incisor. (×45, van Gieson's stain.)

With the gradual accumulation of the histopathologic material comes more and more evidence of the very sensitive balance existing between the alveolar structures and the teeth. Mucous membrane and its underlying fibrous and elastic network of connective tissue elements are closely associated with the changes in the alveolar bone and the contained dental roots. This was brought out strikingly in several animals, of which number 2 is a fair example. In this case there was attempted a reciprocal movement in two maxillary permanent central incisors. The appliance consisted of two bands of iridium and platinum

alloy of 0.005 thickness and a piece of 0.030 round wire, gold platinum alloy, and spring tempered. It was so adjusted on the two teeth that an extrusive pressure was produced on the right central and the opposite force on the left.

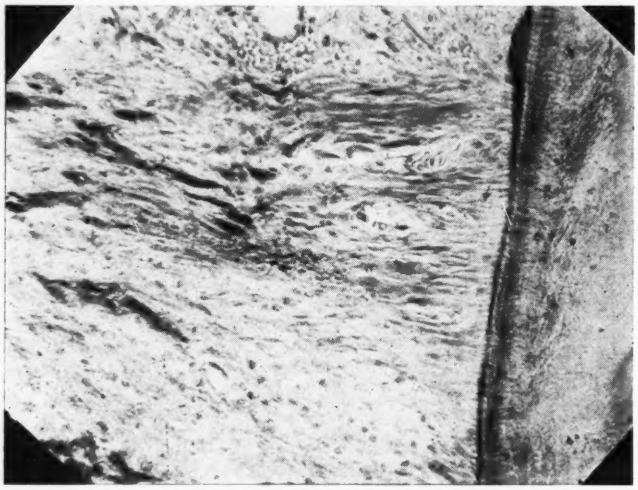

Fig. 9.—The fibers of the approximating tooth have not changed their normal direction.

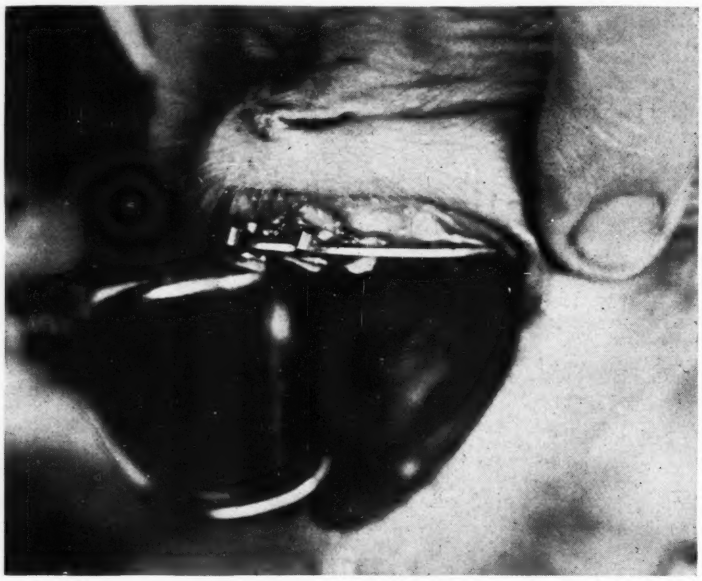

Fig. 10.—One of the appliances employed to produce the tooth movement, animal No. 2, taken December 14, 1928.

The following terms used at various times and places appear in orthodontic parlance to be synonymous:

Extrusion	—	Intrusion
Supraversion	—	Infraversion
Supraocclusion	—	Infraocclusion
Abstraction	—	Attraction
Elongation	—	Depression

The movement of the right central incisor was in the direction of the long axis of the tooth and out of the socket, which I shall call for the moment, "extrusion."

No evidence has shown so far that the pressure exerted in an apical direction (intrusion), accomplished much movement of the tooth, but that pressure was acting on the tooth in question was quite apparent from the radiographic picture, as well as from the histopathologic one.

In the radiograph (in this case an enlarged positive) there is shown the characteristic shortened root with the irregularly blunted apex (Fig. 5).

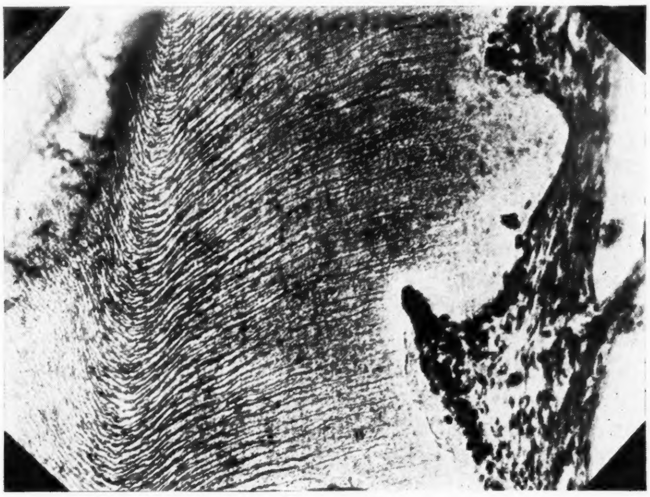

Fig. 11.—Apposition of new tissue following absorption. Partial obliteration of dentinal fibrils due to formation of secondary dentine.

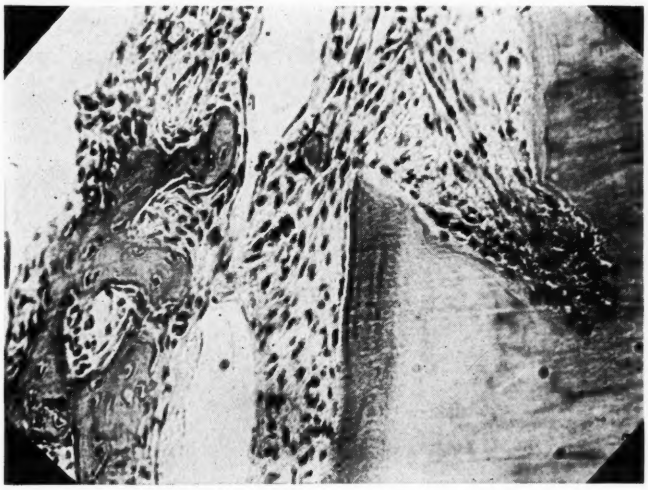

Fig. 12.—Apposition following absorption on distal aspect of maxillary left permanent first molar (×280.) Hematoxylin and eosin stain.

Apically from the residual portion of the root is a radiolucent area, rather narrow but still of sufficient size to indicate a loss of calcified material and an alteration in the soft tissues. The radiograph, however, is not clear-cut. This is due partly to the fact that at the beginning of the experiment there was what appeared to be an incompletely formed apex. Later there developed an inflamed pulp which became necrotic before the animal died. These factors tend somewhat to obscure the result in this particular animal in so far as apical absorption

of the left central incisor is concerned. Fig. 6 from a Mallory stain[6] and Fig. 7 (hematoxylin and eosin stain) show the extent of absorption present and the degree of inflammatory reaction.

In commenting on this experiment, the question that arises first is this: What degree of absorption occurred as a result of the "intrusion" tension of the bands, and where may one say that "here the root formation stopped and here the absorption commenced"? Another point to be considered is this—

Fig. 13.—Pressure absorption due to tipping. Note the eroded cementum. (Mallory's stain.)

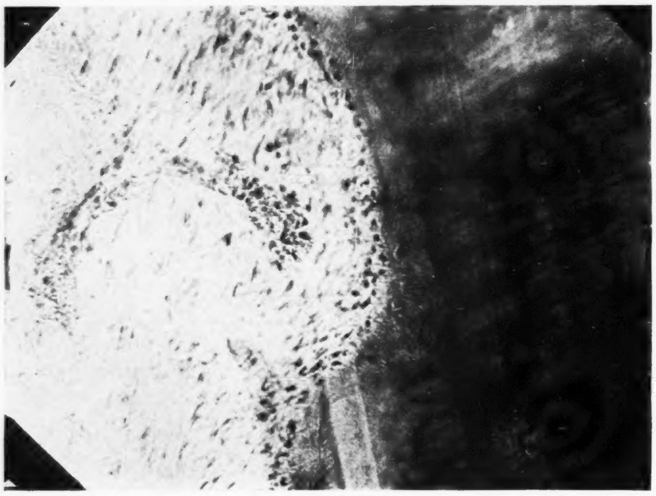

Fig. 14.—Capillary loop in area where active apposition is going on. (×270.) Hematoxylin and eosin stain.

with the necrotic pulp present what effect did this disorganized tissue have upon the surrounding paradentium?

Neither of these questions, in my opinion, can be answered definitely yet. But further experiment and study may indicate several hypotheses. First, that the absorption demonstrated histopathologically was the result of the action of the products of the necrotic pulp upon the paradentium, dentine and cementum. Second, that the tension upon this particular tooth was great

enough to strangle the capillary circulation and thus produce necrosis of the pulp as well as apical absorption. Third, that the absorption had no relation whatever to the orthodontic appliance. If this latter hypothesis is true, then there must be advanced an acceptable explanation for the occurrence of the apical absorption.

With the right central incisor there was a very definite movement of the tooth out of the alveolus (extrusion). All the surrounding tissues were concerned with it, bone, peridental membrane, and mucosa. This is indicated by the fact that the direction of the fibers has been turned toward the occlusal plane almost ninety degrees (Fig. 8).

Under normal conditions the bone lamellae and the transeptal peridental fibers lie in a position nearly perpendicular to the long axis of the tooth. But in this case the tissues were dragged out of this position to one in which the fibers nearly paralleled the tooth root. The interesting point in this connection is that all the structures of the paradentium show quite conclusively the

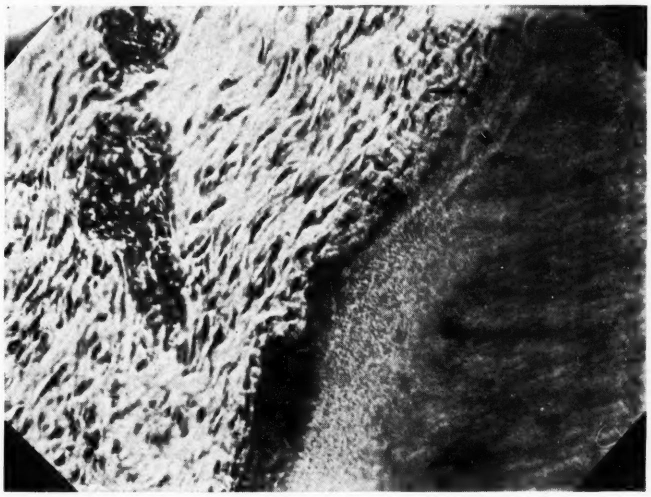

Fig. 15.—Young blood vessel and mesenchymal tissue in an area previously absorbed. (×300.) Hematoxylin and eosin stain.

general direction of stress. But there was no evidence of apical absorption—a finding which was not unexpected.

There is no such picture with the left central incisor on which the force was toward the apex (intrusion). The only effect noted so far was the apical absorption which has been discussed. Neither the fibers nor the bone lamellae changed direction and slanted toward the apex. In Fig. 9, the van Gieson stain indicates that the normal direction of the peridental fibers in this location is unchanged. There is no evidence of any slanting either apically or gingivally. There was, however, a slight inflammatory reaction.

The type of appliance used for this experiment is shown in Fig. 10. It consisted of a square labial arch wire to which were attached two bracket bands on the central incisors.

Of even more interest, however, is the histopathologic picture of induced pressure absorption which developed on the lateral aspect of the mesiobuccal root of the maxillary left first permanent molar.

Following the active period of absorption comes the rebuilding process-apposition. This is clearly demonstrated by a hyaline zone in which the few remaining fibers of the dentine matrix are usually completely obliterated by the newly formed atypical osteocementum, so called because this new tissue may present the morphology of either cementum or bone—but not dentine as shown in Fig. 11 from a Schmorl stain.

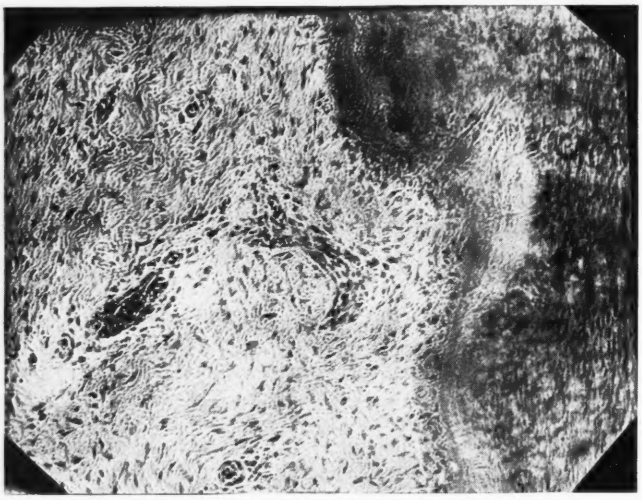

Fig. 16.—New tissue has nearly filled in the absorbed dentine.

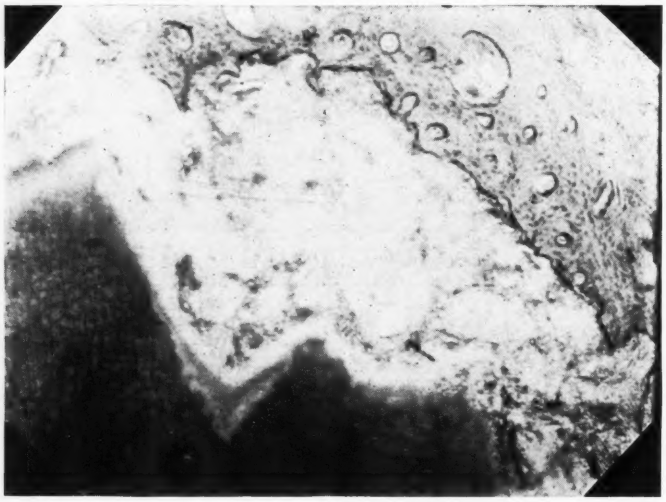

Fig. 17.—Pressure absorption on apex. (×100.) Hematoxylin and eosin stain.

In another case the tipping of the roots of the first permanent molar drove the roots against those of an unerupted second molar. This resulted in partial lateral absorption of the distal aspect of the first molar roots. (Fig. 12.) Here again is shown the hyaline area in which apposition of newly calcified material has occurred.

In another of the experiments the crown of a maxillary permanent first molar was tipped distally. Thus the mesial side of the roots were absorbed to a significant degree (Fig. 13, Mallory).

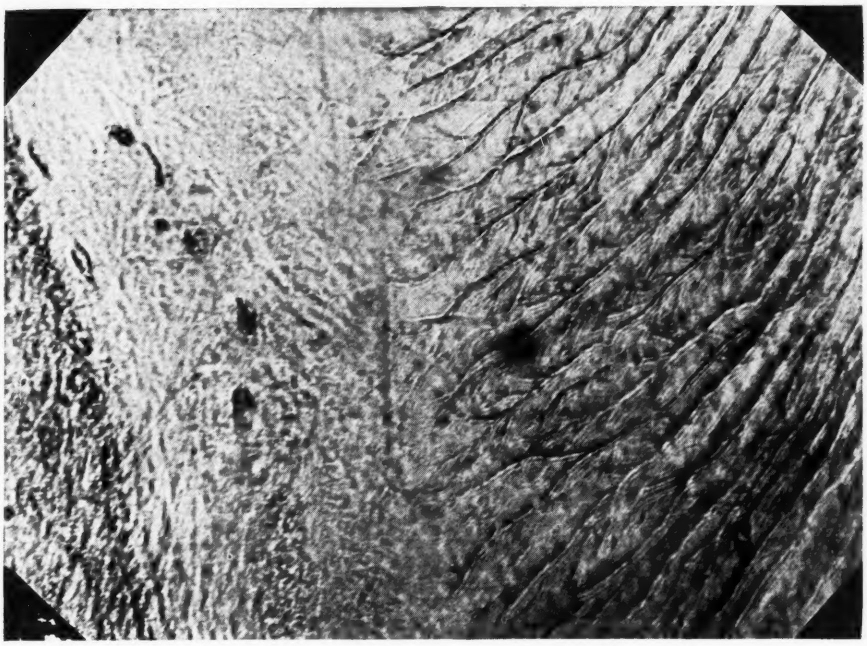

Fig. 18.—Partially obliterated dentinal fibrils and a wider Tomes layer. (×500, Schmorl's stain.)

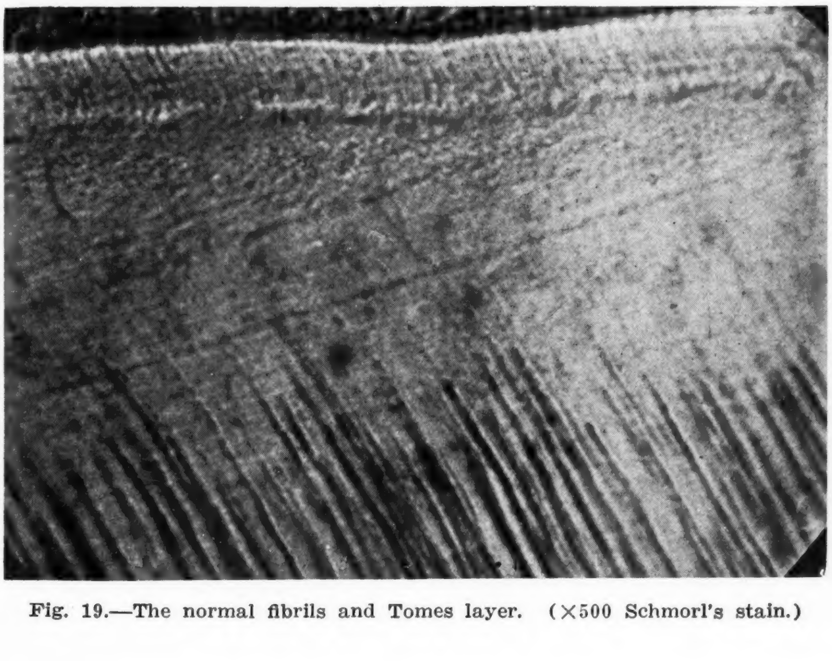

Fig. 19.—The normal fibrils and Tomes layer. (×500 Schmorl's stain.)

One of the mechanisms by which absorption and apposition is accomplished is suggested in Fig. 14. In this case a capillary loop from the peridental membrane is seen almost in contact with the eroded area. In the earlier stages of the process these Howship's lacunae may contain osteoclasts. When the tension produced by the appliance was removed absorption changed to apposition. Just as in the fundamental stage of normal bone development there is mesenchyme, so here, the presence of young blood cells suggests that mesenchymal tissue

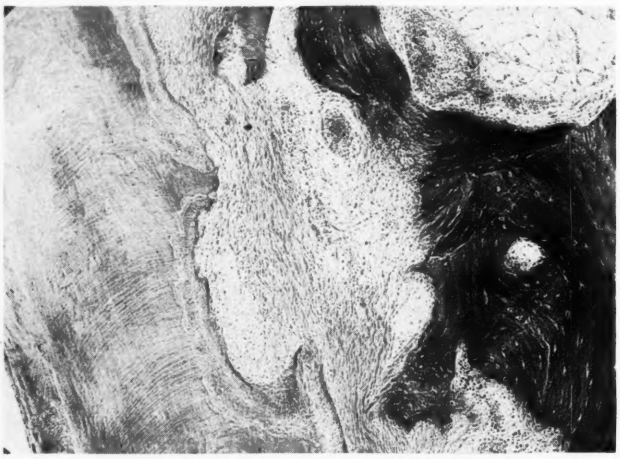

Fig. 20.—Deep lateral absorption followed partly by apposition. (Mallory's stain.)

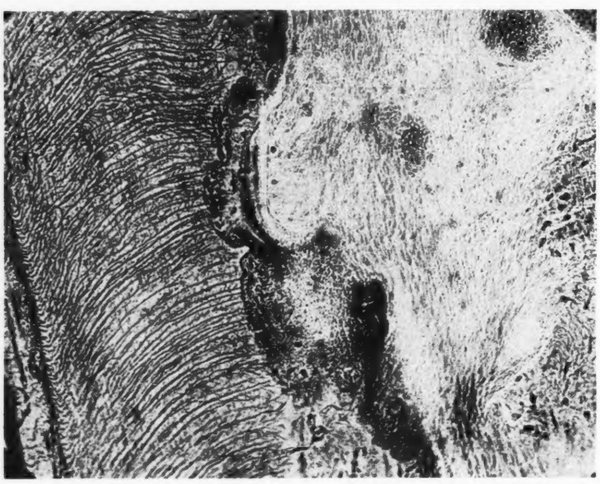

Fig. 21.—Absorbed dentine has been replaced by bone. Low magnification does not show the changes in the fibrils. (×250, Schmorl's stain.)

is present and that consequently the rebuilding process is under way (Fig. 15). Without the young blood vessels, no mesenchymal tissue would be present.

Osteoclasts have been demonstrated in a few of the sections. There have been more instances, however, in which the proximity of young blood vessels in a previously absorbed area indicated that apposition was occurring. In Fig. 16 (hematoxylin and eosin stain) apposition has replaced absorption. Here again is a blood vessel as well as newly formed fibrous connective tissue. The crown of the maxillary molar was tipped distally, for a short time, the induced

malocclusion thus driving the crown of the mandibular molar out of alignment and subjecting it to unusually severe occlusal trauma. Later when the pressure was removed, tissue repair commenced.

The characteristic ragged edge of apical absorption is seen in Fig. 17.

It has been mentioned that the type of response of the dental pulp to a stimulus depends first upon the severity of injury. In cases of slowly developing dental caries as well as in erosion, attrition and abrasion, the pulp frequently undergoes a slow calcific degeneration. This lesion may assume various forms, such as the laying down of pulp stones either attached to the walls of the pulp chamber or canal, or else embedded within the pulp substance. Instead of these larger nodules there may be formed within the tubules a calcified zone which often serves to protect the pulp from further injury. This has been observed by Noyes[7]; Bodecker[8]; Hopewell Smith[9]; Orban[10, 11]; and many other histologists and is known as secondary tubular calcification. Up to now it has been described as associated exclusively with the various lesions mentioned

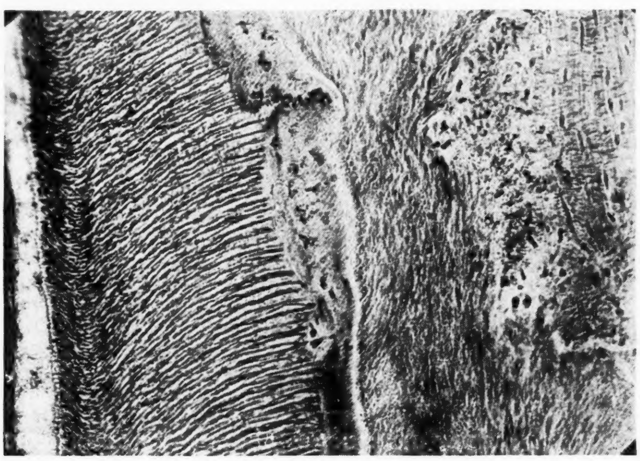

Fig. 22.—Dentinal fibrils, peridental membrane and bone.

above. But it has been found also in some of these cases of experimental orthodontia. In apical absorption the invading peridental membrane excites a reaction sufficient to stimulate the dentine fibrils of the odontoblasts into active function. (Fig. 18 [compare with Fig. 19, normal].)

Thus secondary dentine is formed in the root portion of the dentine tubules. Gradually both tubules and fibrils lose their identity as such and become a part of the ever-widening granular layer of Tomes.

Bone, tooth structure and peridental membrane, all show the effect of mechanical trauma as well as injury from infection (Boulger[12] and Hatton[13]). Luckily there are two processes which usually proceed simultaneously. With absorption goes almost hand in hand the opposite process, apposition. Following the tearing down of dental or osseous structures comes a building up of new material, and this, of course, is occurring with every alteration in *degree, direction, and deviation of stress.* Bone is an exceedingly labile tissue responding easily, apparently, to changes induced by muscular force or impacted teeth (Worman[13]). Tooth structure also appears to be a labile structure re-

sponding to variations in the alignment of teeth and to differences in occlusal stresses. This is indicated in Figs. 20 (Mallory's stain), 21, and 22 (Schmorl's stain) in which absorption has been followed by apposition. Thus the contour of the tooth eventually is rebuilt.

It is not yet clear, however, why apposition does not always occur. Nor can it be stated that absorption of tooth root is followed always by a filling in of bone. The very opposite condition may be seen in hypercementosis, for here a mild irritation (either of an infective or mechanical nature) frequently stimulates the formation of secondary cementum.

However, there is still lacking sufficient evidence upon which to formulate an hypothesis of root absorption.

The differences in normal resorption and pathologic absorption seem to be due to reaction of the pulp to the different stimuli. In the one case the pulp aids the resorption by a tearing down process in which, as I visualize it, the fibrils of the stimulated odontoclasts widen the tubules as they (fibrils) themselves become distended. They are thus brought closer together and are larger than the normal fibrils.

In the second case, exactly the opposite stimulus is applied. Instead of aiding the pathologic absorption the pulp protects itself by throwing up a wall of secondary dentine. This is entirely analogous to the reaction observed by the pulp when the irritation comes from caries, attrition, abrasion or erosion. With a change in severity or direction of pressure the compensating mechanism starts to work and the result is the laying down of a new hard tissue—one which may have the characteristics either of bone or cementum but never of dentine.

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DISCUSSION

Dr. Albert H. Ketcham (Denver, Colo.).—I believe it might be of interest to review briefly the history of this research project. However, I want first to say that I am sure that we are all deeply grateful to Dr. Marshall for the work he is doing.

The resorption of the roots of permanent teeth with vital pulps during orthodontic treatment is a source of great embarrassment and chagrin to the orthodontist. There are many reports from different sections of this country and from Europe that such a condition occurs in about 20 per cent of cases under orthodontic treatment.

About three years ago, when this subject was presented before the Pacific Coast Society of Orthodontists, John Marshall became interested in the problem, and at the earnest solicitation of several orthodontists he agreed to give his services without compensation, even though it meant the sacrifice of time which he should have devoted to recreation, because he was obliged to conduct this research in addition to attending to his regular college duties and his other research work.

President Campbell of the University of California set aside the sum of eight hundred dollars for an addition to their animal houses in order to care adequately for the monkeys used in the orthodontic research work. Dr. Karl Meyer, head of the Hooper Foundation for Medical Research, University of California, offered their facilities and data on all their extensive animal studies, the only stipulation being that the orthodontists should pay for the monkeys and their care, and a laboratory assistant's salary at an estimated cost of three thousand dollars a year. A prominent research worker had estimated that it would cost at least six thousand dollars a year to conduct such a study, on account of the salary of a director in active charge of the research.

This is the first extensive research in biophysics wherein so large a number of animals, mostly monkeys, are being used; some are on well-balanced and some on vitamin deficient diets. It is a research which required a large number of animals in order to reach conclusions of value. Orthodontic appliances have been placed on the teeth of a number of monkeys in each group by Dr. Allen E. Scott and Dr. George Grover. An orthodontist in treating but one patient could not judge much of reactions to orthodontic stimulus. The same is true in moving the teeth of monkeys. Hence the value of statistics from such a large number of animals.

I am pleased indeed to see the results of this last year's work.

An eminent histologist, Dr. Gottlieb of Vienna, wrote a very interesting letter after the receipt of the manuscript of my first paper on this subject (root resorption), in which he pointed out that the principal thing to be hoped for in cases of resorption was apposition or building of new cementum or bone upon the roots of such teeth to increase the area of attachment of the peridental fibers. I have not been able to show this condition radiographically. Now I am very glad to hear that Dr. Marshall states that the microscope does show that we can hope for such a favorable condition.

Dr. Marshall now has a large amount of material ready to be prepared for study, and we shall, with intense interest, await further reports.

STRUCTURAL FEATURES RELATED TO ORTHODONTIC MATERIALS AND APPLIANCES*

By Prof. R. C. Brumfield, New York, N. Y.

INTRODUCTION

IN WRITING of dental gold to the orthodontist from the producer's viewpoint, it is desirable to state that viewpoint clearly and to adhere to it carefully in order that no impropriety may be committed in seeming to tell the orthodontist how to carry out his operations. The conscientious producer, in common with all good workmen, takes pride in his product. He gives his best efforts to its production and much thought and time to the improvement and perfection of his various alloys. He naturally believes strongly in the result as being adequate for the purposes intended, and is usually backed up in this belief by a record of successful use of his product by a number of orthodontists in various parts of the country who are among his customers. In view of his justifiable pride in his product and of his intimate knowledge of it, the manufacturer feels that he is in a position to tell the orthodontist certain things concerning the use of gold alloys, which may be of advantage to both the orthodontist and himself.

The purposes to be accomplished by the use of any particular structure, that is, which teeth are to be moved and in what manner they are to be moved, constitute a field which belongs peculiarly to the orthodontist, and upon which the producer has neither the desire nor the ability to encroach. He should be almost as hesitant about commenting upon the types of structure by which these purposes are to be accomplished, because these types are so often intimately bound up with the purposes to be accomplished and with the anatomy of the mouth. When types of structure are discussed in this paper, it has been done only after consultation with competent authority for which credit has been given.

When the purposes to be accomplished and the types of structure best suited to their accomplishment have been determined by the orthodontist, however, the manufacturer feels that he is qualified by his intimate knowledge of his product to discuss with the orthodontist on a basis of equality the manner of using gold alloys in order to get the maximum of satisfactory service from them.

The orthodontist has a wide variety of materials from which to choose in forming his structures. The percentage of range of the properties of these materials is probably wider than in almost any other structural field. The leading manufacturers in recent years, in answer to a demand for such information, have been engaged in testing their products and tabulating the vari-

*Read at the Twenty-ninth Annual Meeting of the American Society of Orthodontists, Nashville, Tenn., April 8-11, 1930.

ous physical properties of their alloys. These tabulated results are obtained only after making hundreds and even thousands of tests at a very considerable expense invested in apparatus and testing personnel. These results are available to users of dental gold for their guidance in selecting materials for their various structures as the purposes for which each structure is to be used may dictate.

The availability of a table showing the physical properties of the dental gold alloys which he may use is, however, not a complete answer to the orthodontist's problem. He requires of his structure sufficient strength to accomplish its purpose without rupture and without any permanent change in form, enough stiffness to exert the forces required with permissible distortions, and sufficient lightness to give as little discomfort in the mouth as possible. The interpretation of these desirable properties of the finished structure from the published test results of the individual alloys from which the structure is to be made is not an easy matter. If completely done it involves, in addition to a knowledge of the properties of the materials, a knowledge also of the forces which are to come on the structure and of the effects of these forces in inducing stresses in the various members of the structure. Both these last named branches of information have been very little investigated, and this lack of knowledge emphasizes the difficulty of the orthodontist's problem. Yet without some practical means of reading from the published physical properties of the gold alloy the desirable properties of the finished structure, the test results which the manufacturer has furnished the orthodontist are of no direct use to him and may even be a hindrance through the creation of confusion. It is to be hoped that such information may be supplied in future courses in the dental schools and through postgraduate courses. Of its present lack there seems to be no question. This paper is an attempt to supply this deficiency to a certain extent.

STRENGTH

Any structure, when subjected to external forces, suffers a distortion due to these forces. Counteracting forces called *stresses* are induced within the material of the structure due to this distortion, which tend to oppose the distortion caused by the external forces. When the distortion caused by the external forces is sufficient to induce large enough internal stresses within the material, distortion ceases and a state of equilibrium exists with the external forces balanced by the internal stresses according to definite laws which may or may not be known, depending on the circumstances of the case.

Three kinds of stresses and three kinds only may be induced in a structure as a result of external forces, no matter how complicated. These stresses are: tensile stress, which is a stress tending to oppose elongation of the material in a direction parallel to the line of action of the stress; compressive stress, which tends to oppose shortening of the material in a direction parallel to the line of action of the stress; and shearing stress, which tends to oppose sliding of one plane of the material over the next adjacent plane in a direction parallel to the line of action of the stress.

It is in terms of the intensities of these three kinds of stress which materials are able to withstand that their physical properties are reported. The strength of the finished structure, however, is interpreted in terms of the value of the external load of some given character which the structure can withstand. It is, therefore, evident that the successful prediction of the strength of the finished structure from the known physical properties of the material from which the structure is built depends upon a knowledge of the laws by which stresses are induced within a given structure by a given type of external force. The structural engineer has worked out these laws for certain types of structures which fit his needs for buildings, bridges, etc., but for most of the structures of orthodontia they are unknown or only partially known. We are forced then at the outset to admit that many of these structures cannot be designed directly.

We can, however, use a comparative basis for the semidesign of such structures with great advantage. If we assume as a starting point a structure of a given type which has been evolved from some known alloy with proper dimensions to serve successfully a given purpose in the mouth, it is then possible to interpret comparatively on the basis of the satisfactory strength of that structure, the strength of similar structures made from all other available materials in terms of the physical properties of those materials. We can predict what the comparative strength of the structure would be if made in the same dimensions from any other material. We can tell by what percentage to alter the dimensions of the structure in order to retain the same strength using a different material. If the strength of the original or base structure has not been satisfactory, we can tell how to alter the dimensions in order to increase or decrease the strength by definite percentages either at a given point or throughout. Thus we are able, starting with a given base structure satisfactorily evolved from a known material for a definite purpose, which accordingly represents the best experience of the orthodontist responsible for it, to interpret this structure for him in terms of all other available materials and dimensions. This broadens his initial experience immensely without additional effort on his part and has the advantage of combining theory and experience ideally in an otherwise difficult situation.

The accomplishment of these ends depends upon certain fundamental principles and assumptions which must be clearly stated in order that they may not be violated in the use of the results. This statement is not meant to indicate that the use of these results is decidedly limited. It is believed that the bases upon which they are arrived at are broad enough to take in 95 per cent of dental structures. The above statement is made simply to guard against the use of the results foolishly on the occasional structure which may obviously violate the fundamental principles stated.

The first assumption made is that the maximum stresses induced within the structure by whatever external loads may come on it in use are well within the proportional limit of the material of which the structure is composed. It is believed that this must necessarily be so in any structure which

has given satisfactory service; otherwise permanent distortions would have occurred.

Second, it is assumed that the critical stresses which limit the strength of the structure are induced primarily by bending forces. By bending forces we mean any forces which when applied to the structure tend to change the curvature of the members of the structure from that curvature which they had in the unstressed condition. While it is recognized that stresses due to bending are often combined with those due to direct tension or compression in the structure, all types of stress being induced by the same force, it can be shown mathematically that the direct tensile or compressive stresses become practically important only as compared to the total when the eccentricity of the forces producing them is less than one-eighth of the thickness of the member in which the stresses are induced. This condition is ordinarily unlikely to occur in orthodontic appliances.

Third, it is assumed that the general (not the detailed) form and dimensions of the two structures compared are essentially the same. This assumption is necessary in order that the unknown factors, such as the sort of forces which come on the structure, the laws by which stresses are induced within the structure, and so forth, may be the same for both structures and so not affect conclusions.

The general law by which tensile and compressive stresses are induced in a beam subject to bending forces is expressed by the following equation:

$$L = \frac{K\,P\,d^3}{a}$$

In this formula L is the external force which is applied to the beam. K is some constant which depends upon the following factors: the type of beam, the type of loading, the length of beam, the shape of the cross-section of the beam, and the ratio which the stress induced within the structure bears to the proportional limit of the material of the structure, or what is ordinarily termed the factor of safety. P is the proportional limit of the material of the structure, and d is the dimension of the beam in the plane in which bending takes place and at the section of maximum stress. The length of the beam is denoted by a. Thus it will be noted that strength depends upon both material and character of structure. The character of structure, in fact, contributes more variables in the final expression for strength than does the material.

In comparing two structures of similar form and general dimensions we are justified in assuming that because of this similarity K and a for the two structures are identical and will accordingly cancel each other, thus eliminating the large number of unknown factors involved in K. Such a formula for comparative purposes would then be written:

$$L = \frac{L_1\,P\,d^3}{P_1\,(d_1)^3}$$

where L, P and d have the same significance as before for one of the structures and the same characters with the subscript $_1$ refer to the same prop-

erties of the other structure. In this formula we have eliminated all unknown factors and are able to compare strengths with different dimensions, to compare dimensions for different strengths, to compare strengths using different materials, to compute dimensions using different materials while the strength is retained the same or is increased or decreased by definite amounts. A partial table for wrought wires has been included below, computed on this basis with wide enough scope to take in the whole list of wrought wires available to the orthodontist. The complete table has not been included here because of lack of room, but these tables together with tables for the use of cast golds may be had on request, by members of the profession, to the J. F. Jelenko Co., New York, N. Y. It is felt that the use of these tables by the orthodontist in selecting his materials and in building his structures will add considerably to his understanding of the possibilities offered him through the variety of materials available, and thus contribute substantially to the satisfactory service of his finished structures.

EXPLANATION OF USE OF PARTIAL TABLE

This table has been computed on the assumptions that stresses are within the proportional limit of the material and that critical stresses which determine the useful strength of the structure are primarily due to bending forces. The table may be used for comparing the strengths and flexibilities of any two structures of the same general form made from wires of different materials whose diameters may vary as much as 20 per cent in either direction. Round wires may be compared to round wires and half round wires to half rounds by the table, but no attempt should be made to compare half rounds to rounds. Another table is provided in the complete bulletin by which this latter comparison may be made.

Although the general form of the two structures compared should be the same, it is not essential that the general dimensions be identical to obtain useful results from the table. For instance, a variation of 10 per cent in the general dimensions of the structures which are the leverages of the bending forces, might ordinarily be expected to change conclusions as to strength as read from the table, ignoring this variation, inversely by about the same percentage.

The number at the left outside the bracket in each case represents approximately the proportional limit in pounds per square inch of the material of the base structure the form and dimensions of which have been determined by experience. The numbers in the next column to the right enclosed by the bracket represent the proportional limits of possible materials from which the same structure might be made with changes in strength and flexibility as indicated in the double columns horizontally opposite the indicated proportional limits.

The figure on the left of each double column in each case indicates the percentage of change in strength and the one on the right the percentage of change in flexibility corresponding to the changed strength as compared to the base structure under the conditions indicated at the heads of the respec-

tive double columns. The plus and minus signs indicate percentages of increase or decrease over the properties of the base structure.

The flexibilities have been computed on the assumption that the moduli of elasticity of the materials vary with the proportional limits from a low of 14,500,000 pounds per square inch corresponding to a material whose proportional limit is 60,000 pounds per square inch, to 18,000,000 pounds per square inch corresponding to a material whose proportional limit is 130,000 pounds per square inch. While this assumption is not strictly true in all cases, it is approximately true, and slight variations from it will not affect results appreciably.

The factor or margin of safety in the compared structure will always be the same as that of the base structure whatever that may be. That is, the proportional limit of the material of the compared structure bears the same ratio to the working stresses in the compared structure as the proportional limit of the base structure material bears to the same stresses in the base structure.

As an example of the use of the table, suppose we have been using in a given structure satisfactorily a wire of given diameter from a material whose proportional limit is 100,000 pounds per square inch and we wish to study the effect on this structure of changing diameter and material. Looking in the part of the table where 100,000 appears outside the bracket at the extreme left, we see that if we wish to retain the same strength we may use a wire 10 per cent less in diameter, using 130,000-pounds-per-square-inch material and hold the strength practically constant, decreasing only 5 per cent. The flexibility necessary, however, to develop this strength is 32 per cent greater than that of the base structure. If we use 60,000-pounds-per-square-inch material of the same size, we decrease the strength 40 per cent and the flexibility 32 per cent.

If published proportional limits are not exactly as indicated in the tables, interpolation will give slightly more accurate results than will be had by taking the nearest tabular value to the published proportional limit.

It cannot be too strongly emphasized that the increased flexibilities (under constant loads) possible to obtain with high strength golds over those possible from golds with lower proportional limit are only possible when the cross-sectional dimension is reduced. When the cross-sectional dimension is retained, the same high strength gold will always give greater stiffness for the same load. Local changes in strength in a structure may be had by altering the cross-sectional dimensions of the structure locally as indicated by the table. If the indicated changes in flexibility are desired, the cross-sectional dimensions of all the parts of the whole structure must be altered as indicated, however.

This table may also be applied to pure torsion or to torsion and bending such as is encountered in the vertical shank of the Gillette clasp.

FLEXIBILITY

The flexibility of a structure is measured by the amount of movement or distortion of some given character which it undergoes as a result of the

TABLE I

COMPARATIVE STRUCTURAL SERVICE OF MATERIALS OF ORTHODONTISTS

PROPORTIONAL LIMIT OF BASE STRUCTURE MATERIAL LBS. SQ. IN.	PROPORTIONAL LIMIT OF COMPARED STRUCTURE MATERIAL LBS. SQ. IN.	PERCENTAGES OF CHANGE OF STRENGTH AND FLEXIBILITY OF COMPARED STRUCTURE OVER SAME PROPERTIES OF BASE STRUCTURE FOR THE PERCENTAGES OF DIMENSIONAL CHANGE INDICATED AT THE HEADS OF COLUMNS													
		TYPICAL WIRE SIZES INCHES													
		0.016 0.024 0.032		0.018 0.027 0.036		0.019 0.0285 0.038		0.020 0.030 0.040		0.021 0.0315 0.042		0.022 0.033 0.044		0.024 0.036 0.048	
		PERCENTAGE OF DIMENSIONAL CHANGE													
		−20		−10		−5		0.0		+5		+10		−20	
		STR.	FLEX.	STR.	FLEX.	STR.	FLEX.	STR.	FLEX.	STR.	FLEX.	STR.	FLEX.	STR.	FLEX.
60,000	130,000	+10	+117	+57	+93	+85	+83	+116	+73	+150	+65	+187	+57	+274	+44
	120,000	+3	+107	+46	+84	+72	+74	+100	+65	+132	+57	+166	+50	+246	+37
	110,000	−7	+94	+33	+73	+57	+64	+83	+55	+112	+48	+143	+41	+217	+29
	100,000	−15	+82	+21	+62	+42	+53	+66	+46	+92	+38	+120	+32	+188	+21
	90,000	−23	+70	+9	+51	+29	+43	+50	+36	+74	+29	+99	+23	+160	+13
	80,000	−32	+55	−3	+38	+14	+30	+33	+24	+54	+18	+77	+13	+131	+3
	70,000	−40	+40	−15	+25	0	+18	+16	+12	+35	+7	+55	+2	+101	−7
	60,000	−49	+25	−27	+11	−14	+5	0	0	+16	−5	+33	−9	+73	−17
100,000	130,000	−34	+48	−5	+32	+11	+25	+30	+19	+50	+13	+73	+7	+126	−1
	120,000	−37	+42	−12	+26	+3	+19	+20	+13	+40	+8	+60	+3	+108	−6
	110,000	−44	+33	−20	+18	−5	+12	+10	+6	+28	+1	+47	−3	+91	−12
	100,000	−49	+25	−27	+11	−15	+5	0	0	+16	−6	+33	−10	+74	−17
	90,000	−54	+17	−34	+3	−22	−2	−10	−7	+5	−12	+20	−16	+57	−23
	80,000	−59	+6	−42	−6	−31	−11	−20	−15	−7	−19	+7	−23	+39	−30
	70,000	−64	−4	−49	−15	−40	−19	−30	−23	−19	−27	−7	−30	+21	−36
	60,000	−69	−15	−56	−24	−48	−28	−40	−32	−30	−35	−20	−38	+4	−43

PERCENTAGES OF CHANGE IN BULK CORRESPONDING TO DIMENSIONAL CHANGES

Percentages Increase in Dimension	% Increase in Bulk
+5	+10
+10	+21
+20	+44
Percentages Decrease in Dimension	**% Decrease in Bulk**
−5	−9.8
−10	−19.0
−20	−36.0

application of an external load. This load, however, must not be great enough to produce permanent distortion. This property of the structure is very important to the orthodontist. As pointed out later, good flexibility is useful in absorbing the uncertain effects of sudden or impact loads. Permissible flexibility may be limited by the place in which the structure is to be used and thus become important in determining the type of structure. The amount of distortion of the structure is always a direct measure of the external load, within the proportional limit of the material, and thus may become important to the orthodontist as an indicator of this load. Flexibility may be also used as a gauge of the safe loading of the spring to avoid overstressing and breakage. An example of this, as applied to orthodontia, is found in the case of auxiliary springs. Here, as pointed out later, the deflection of the point of the spring is a direct measure of the pressure exerted on the tooth to be moved and the stress in the spring (see Table II).

As in the case of strength the maximum permissible deflection of beams subject to bending may be expressed by a general formula as follows:

$$f = \frac{C\ P\ a^2}{E\ d}$$

In this formula f represents the deflection of the beam. C is a constant which is controlled by the following factors: the type of loading, the type of beam, and the factor of safety of the material of the structure based on the proportional limit of the material. P is the proportional limit of the material of the structure, a is the length of the beam, d is the depth of the beam in the plane of the bending, and E is the tensile and compressive modulus of elasticity of the material of the beam. The tensile modulus of elasticity is defined as the ratio of the unit stress in tension in a tensile test piece at any point within the proportional limit to the corresponding unit elongation and is expressed in terms of pounds per square inch.

Again as discussed under strength, for comparative purposes the factors C with their unknowns are common to the two structures of the same form and general dimensions and will accordingly cancel out. This is also true of the length a. The comparative formula will then be written:

$$f = \frac{f_1\ P\ E_1\ d_1}{P_1\ E\ d}$$

In this formula the characters have the same significance as above, those with subscripts referring to one structure and those without to the other. In computing tables according to this formula the assumption has been made as explained in connection with the table, that the modulus of elasticity varies with proportional limit. While this is not strictly true, it does not depart from the truth sufficiently to destroy the practical usefulness of the results.

It will be noted from the first formula given under *Flexibility* that the flexibility varies directly with the load and the square of the length and inversely with the modulus of elasticity and the cross-sectional dimension. Since the square of the length of the beam is involved, the length then becomes the most important variable factor quoted in influencing flexibility. The other

variables all affect flexibility according to the first power of the variable, and equal percentages of change in these variables would have approximately equal percentages of effect on the flexibility.

As an example of the use of the table computed from this formula, consider a structure whose material has a proportional limit of 100,000 pounds per square inch compared to a similar structure whose material has a proportional limit of 130,000 pounds per square inch. The tables indicate that the latter structure is 30 per cent stronger and 19 per cent more flexible than the former. It should be noted that this increased flexibility is attained, however, not under the same load as is applied to the structure, but under a load which is 30 per cent greater. If we wish to compare the two structures as to flexibility under the same load we proceed as follows: since within the proportional limit, load is proportional to deflection, reducing the load of the high strength structure by 30/130 would reduce the deflection by the same proportion. 100/130 x 119 is equal to 91, or the high strength structure under the same loading is only 91 per cent as flexible as the low strength structure. The high strength structure without dimensional change attains its increased flexibility only under the increased load possible as a result of the high strength.

It will be noted that if the cross-sectional dimension is reduced as is indicated in the table under the heading −10 per cent the strength of the two structures is practically the same, and the flexibility of the high-proportional-limit structure is 32 per cent greater than that of the low-proportional-limit structure. Since we cannot escape the conclusion that two structures designed for identical purposes would be subject to the same loads, it is obvious that comparing two structures, one of higher strength material than the other, the greater flexibility to be expected from the high strength material can be attained only by reducing the cross-sectional dimensions.

The relative flexibility to be chosen for any given structure is a matter which must of course be left to the individual orthodontist. In general, high flexibility will go with lightness and ability to withstand shock and sudden loads without damage. If, however, for any reason the amount of flexibility is limited by the place in which the structure is used or by the purpose for which it is intended, such local conditions may dictate the maximum amount of flexibility permissible.

IMPACT RESISTANCE

The value of an impact force in producing effect on the structure is what is termed the kinetic energy of the force. This quantity is measured not only by the value of the force but by its velocity or rate of application. In other words, the value of the force itself may be small, but if its velocity is great the kinetic energy represented by it may be quite large.

A structure which is subject to such an impact force must absorb the kinetic energy represented by that force. The manner of absorption and measure of the ability of any structure to absorb kinetic energy are given by the formula:

$$U = K\,S^2\,V$$

in which U is the energy absorbed, K is a constant quantity depending upon the

type of structure and material. S is the maximum stress induced within the material of the structure and V is the volume of the structure.

This formula is illustrated in Fig. 1. The capacity of the structure to absorb energy is represented by a box two sides of which are the stress in the structure and the third of which is the volume of the structure. K would represent a variable number of boxes all alike. The total capacity of these boxes would represent the ability of a structure to absorb impact. The energy is represented as entering these boxes by means of a chute which is the flexibility. The chute leaks. The leakage represents loss of energy through vibration and in other secondary manners. The longer the chute the more chance for leakage and the less energy necessary to put into the box.

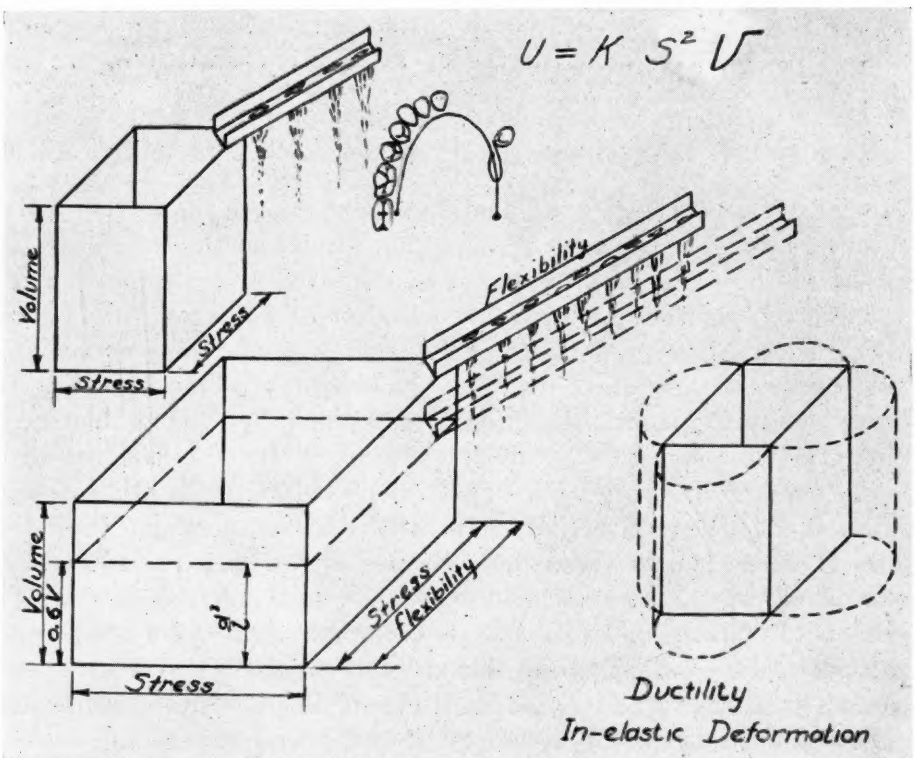

Fig. 1.—Illustrating the relative powers of absorption of energy by materials both within and beyond the proportional limit.

From the standpoint both of absorbing energy and of dissipating it in secondary ways, it will be noticed from the drawings, which are to scale comparatively, that the structure of high strength material is far superior to that of low strength material, even when the former is cut down in volume, as indicated by the dotted lines, so that the static strengths are equal. This is true, but everything said presupposes that stresses are within the proportional limit.

It is always desirable to keep stresses within the proportional limit, but should they exceed that limit occasionally because of unforeseen circumstances, it is also desirable that the structure be not destroyed by this occasional overstressing. This case is represented by the box shown with the bulging sides

at the lower right of Fig. 1. The bulge represents the fact that the structure is permanently distorted by overstressing, and the increased volume of the bulged box represents increased capacity for impact. This drawing is not to scale.

The amount of such bulge for a given material before rupture takes place may be much greater than that indicated and is measured by the percentage of elongation or ductility of the material. Low strength materials sometimes far exceed high strength ones in this respect, and in choosing a material we must select one with enough bulge possibilities or percentage of elongation to cover the uncertainties of our loads. After this has been provided for, the higher strength material is the better from an impact standpoint.

The percentage of elongation of wrought wires, in my judgment, should not be less than 2 or 3 per cent based on the eight inch length, or 4 to 6 per cent based on the two inch length for satisfactory service in the mouth. Greater elongations are of course desirable, other things being equal.

HEAT TREATMENT

Methods of heat treatment of dental golds have been thoroughly discussed in dental literature previously. We shall not discuss methods here but rather emphasize the need for heat treatment of the structure. A study of almost any table of the physical properties of dental golds will show the fact that it is possible to raise the proportional limit of high grade wires as much as 75 per cent by proper heat treatment. A further study of the foregoing tables of strength will also show that such increases in proportional limit increase the strength of the structure by about the same percentage over the strength in the soft condition, or give possibilities of reducing the dimensions and weight of the structure materially. In fact, if the proportional limits in the material of much greater than 75,000 lb. per square inch are to be utilized, heat treatment must be resorted to. Gold wires have not been developed with proportional limits much above 75,000 lb. per square inch which are not subject to heat treatment or which attain this strength regardless of heat treatment.

If heat treatment is to be used, as it should be on wires which are decidedly affected by it, such heat treatment should be intelligent and controlled. It is true that wires may be hardened by heating in the gas flame and cooling out in air, on a hot plate or by other approximate methods, but because of lack of control the resulting structure is liable to be spot hard rather than of uniform quality. The accompanying ductility of the material is also unknown. Such spot hardening is particularly bad in detracting from the ability of the material to withstand impact stresses. Heat treatment when necessary should be carried out in as nearly the manner prescribed for the particular gold being used as is possible. It is desirable to have a heat treating furnace and means of temperature control for the best results.

ENDURANCE OR FATIGUE IN CONNECTION WITH DENTAL GOLDS

The phenomenon has often been observed in connection with the use of metals that loads repeatedly applied to the structure an enormous number of times, even though they may induce stresses well within the proportional

limit of the material, will eventually cause failure. Such a failure is termed an endurance or fatigue failure. The failure is always characterized by a lack of any measurable elongation of the member or of any reduction in area at the point of rupture. The member simply falls apart without warning of any kind. The fracture is characterized by the fact that the crystalline structure of the metal stands out clearly so that in many cases it is possible to pick out the individual crystals with the naked eye. This appearance of the fracture led at one time, before the fact that metals are crystalline under all conditions was widely realized, to the hasty conclusion that the metal had crystallized in use. This conclusion has held very tenaciously in the minds of users of metals, even though it has repeatedly been shown to be erroneous, and is heard even now from men who should be better informed.

The phenomenon of fatigue failure at stresses which are computed to be well within the proportional limit of the material is explained by the fact that in computing such stresses under the peculiar conditions of repeated stress, one of the most fundamental of engineering assumptions is misapplied. Engineers have always assumed that stresses induced within a material were uniformly distributed: that each square inch had the same stress induced upon it as any other square inch similarly placed. This assumption for most engineering purposes has been justified by a long satisfactory record of practical use. Investigation of the phenomenon of fatigue failure, however, has shown that it is one thing to assume that each square inch has the same stress as another similarly placed and quite another to assume that much smaller areas, say a millionth of a square inch, which might approximate the area of a single crystalline grain, have the same stress. When we consider the haphazard fashion in which the crystalline grains of a piece of metal are arranged as to size, orientation of axes and shape of boundaries, etc., it would seem extremely unlikely that the grains would be uniformly stressed in transmitting a load from one point to another. The fact is that the stresses on single crystalline grains are highly nonuniform and only become uniform on larger areas, such as a square inch, through the working of the law of averages. Microscopic and submicroscopic flaws, as well as sharp corners, scratches and so forth, also tend to produce nonuniformity of stress at numerous points throughout the material. From this explanation it is obvious that while the computed stresses, on the uniform distribution theory, may be well within the proportional limit, the stress on a few individual crystalline grains within the structure which are so unfavorably situated as to have high stress induced may be beyond the proportional limit. This would not do appreciable damage to the structure under a single application of an external load, but if this load is repeatedly put on and taken off, the resultant friction and heat produced in some one of these few overstressed grains will cause rupture in a single grain which then passes its condition of overstress to adjacent grains. They in turn go through the same cycle. Thus fatigue failure is a progressive creeping movement from grain to grain, only a few being affected at one time, until after sufficient reapplications of the load failure of the whole piece results. The highly localized character of the overstress and the resulting

failure explain the lack of measurable elongation or reduction in area and also the striking crystalline appearance of the fracture.

The accompanying photograph of a fatigue crack in a piece of Armco iron (Fig. 2) was loaned to me by Prof. H. F. Moore of the University of Illinois. The photograph emphasizes the extremely local character of fatigue failure in that no slip lines or other effect of the failure can be noted on adjacent grains. This absence of slip lines is not true under all conditions, however.

In my opinion, the dental profession has been misled in regard to the significance of tests for endurance value of dental golds. The only recognized significant result of such tests is the endurance or the fatigue limit of the material. This may be defined as that unit stress produced with a given character of repeated load above which failure will eventually occur and below which failure will not occur, even though the load be reapplied an enormous number of times. No tests to determine this value of dental gold have been

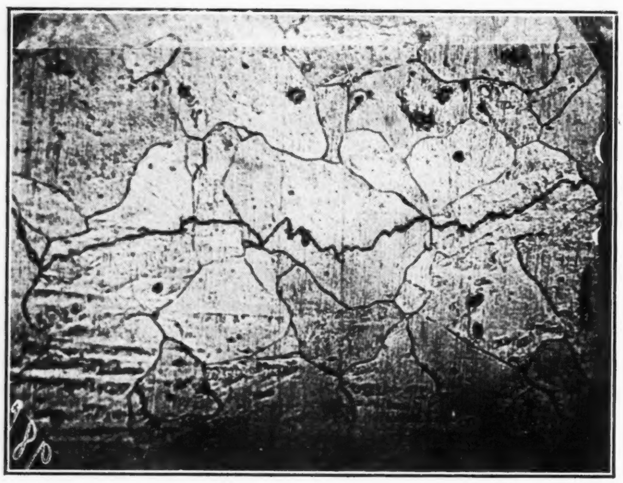

Fig. 2.—Fatigue crack in a piece of Armco iron, emphasizing the extremely local character of fatigue failure through the absence of slip lines in grains adjacent to the crack. (Courtesy Prof. H. F. Moore.)

made. The so-called life tests made by the Bureau of Standards and described in their Research Paper No. 32, December, 1928, were all run at a constant stress above the proportional limit in most cases, and in these tests no attempt was made to determine the endurance limit. Opinions may differ as to the value of such tests as the Bureau did run, but their value as a means of selecting the proper gold best to resist repeated stresses is worse than nothing because the results are misleading. I shall quote from the "Report of the Research Committee on Fatigue of Metals," which will be found in the 1929 proceedings of the American Society for Testing Materials, in justification of this statement. The report says:

"Nearly every investigator who begins the study of fatigue of metals is impressed with the ease and speed of making tests by applying a repeated high stress of some definite magnitude to specimens of different metals and noting the length of endurance of each metal. The committee wishes to point out that as a *measure of the ability of metals to withstand repeated working*

stresses this method is utterly unreliable. Under severe overstress the length of life of a material depends fully as much upon ductility as upon fatigue strength. If a series of metals was tested in this way and the metals were listed in the order of length of endurance, this list would not in general show the arrangement of the same metals in order of fatigue strength under working stresses."

The report from which this quotation was taken was signed by Prof. H. F. Moore of the University of Illinois, chairman of the committee, who is one of the best informed men in the world today on the subject of fatigue in metals. The quotation refers to exactly the type of tests run by the Bureau of Standards on dental golds, and in my opinion fully justifies the statement previously made that the results are worthless.

Under the present status of knowledge of the relative endurance limits of dental golds, when failures of dental structures occur under conditions of variable or repeated stress, the conclusion should not at once be arrived at that the endurance limit of the alloy used is low. As to whether it is or is not we have no present information upon which to base a judgment. Such failures are more likely to indicate a condition of overstress at the point of failure and a consequent necessity of strengthening the structure at that point without changing material.

Under certain conditions it may become necessary, because of lack of space in which to get enough metal, to construct a structure which admittedly will be overstressed in use. In such cases the designer expects the structure to have a limited life when he makes it. As implied in the quotation above, he will do well to select as his material for such a structure one with as great ductility or percentage of elongation as is consistent with other requirements, as the more ductile metal will withstand high repeated overstress better than the brittle ones.

SOLDERING

Soldered joints are necessary in orthodontic appliances under current practice. We will discuss three points in connection with soldering: the selection of the solder to be used on a given alloy, the location of the soldered joint, and the character of the soldered joint.

Solders must always be of sufficiently low melting point to flow at temperatures low enough to leave the material of the main structure solid and with sufficient strength to retain its shape during the soldering operation. This is not always sufficient, however. Many of the gold alloys in reaching temperatures near their melting points undergo a decided grain growth accomplished by the merging of several small crystalline grains into a single large one, even at temperatures which allow the shape of structure to remain unimpaired. It has long been recognized that a large, coarse-grained structure in a metal is conducive to lack of strength and brittleness. A solder, therefore, the flowing temperature of which is so high as to bring about this condition of grain growth in the material of the structure, is undesirable even though the soldering operation may be carried out without impairment of the shape of the structure. The safe margin in degrees of temperature between the melting points of the solder and of the material to be soldered has never

been satisfactorily determined. We have used as a tentative recommendation at various times a spread of 100° F. between the upper limit of the melting range of the solder and the fusion temperature of the wire as determined by the wire method described in the publications of the Bureau of Standards. Whether this spread is sufficient again depends somewhat upon the operator. The longer the time consumed in completing the operation, the greater will be the spread required. The gold solder alloys with the surface of the material to be soldered under the high temperatures of the operation, thus changing the melting point of the surface material. The longer the high temperature is maintained, the deeper this alloying penetrates, so

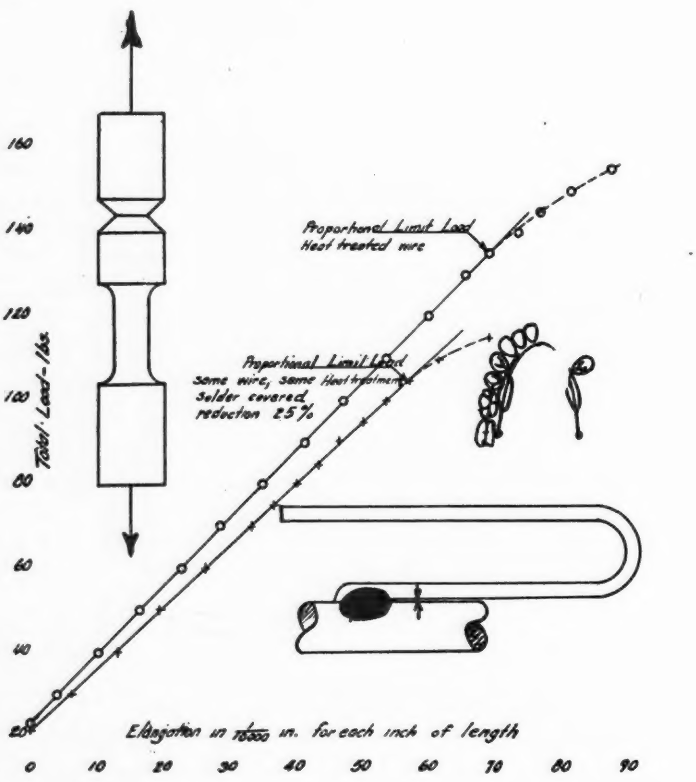

Fig. 3.—Showing the effect of solder on the strength of wire.

requiring a wider spread of melting points for prevention of loss of form. *Speed of completing the operation is, then, one of the essentials of successful soldering.*

The strength of the structure at the soldered joint depends upon two factors: the strength of the solder forming the union and the amount that the surface alloying has altered the physical properties of the material of the structure. Particularly in the use of high strength alloys it is unlikely that either the solder or the alloyed surface material is as strong as the original material. I have test records (Fig. 3) made from high strength gold alloys, which were drawn through a globule of solder retained molten in the furnace and thus solder coated on the surface, in which the proportional limit of the high strength wire was lowered as much as 20 or 30 per cent by

such solder coating. This percentage would undoubtedly be higher if the alloying process were allowed a longer time in which to take place. The solder itself is also usually weaker than the high strength material.

All of this emphasizes the fact that soldered joints should not be located at points of maximum bending moment or stress. That is, since the soldered joint is usually a weak point, it should not be located at points where maximum stresses are induced. A good example of the proper location of the joint as compared with the improper location is given later in comparing the usual present-day practice in auxiliary springs with the original practice. (See Fig. 4 for proper location of joint.)

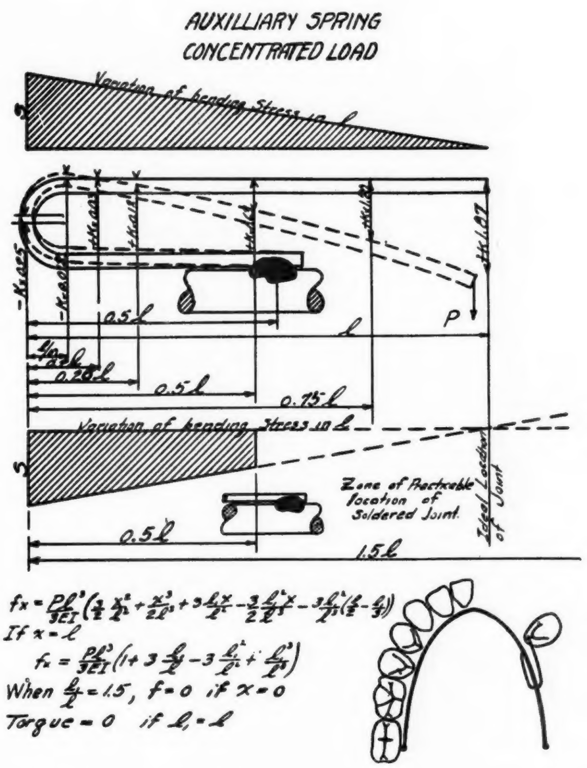

Fig. 4.—Showing the variation of stress and deformation in an auxiliary spring under a single concentrated load.

Soldered joints should be as thin as possible. Material will show a higher strength on short lengths than on long lengths. This is illustrated in Fig. 3. In this case if the tensile test bar shown in the figure is broken at the V notch, it will show about 25 per cent higher breaking strength than if broken at the turned-down section. This is due to the fact that length is not allowed for the destructive shearing distortions, which are preliminary to rupture, to occur in the case of the V notch while it is allowed in the case of the turned-down section. We may infer from this test cited that the thinner the soldered joint is, the stronger it will be for similar reasons. Also, the less distance back from the joint the solder is spread, the better it will be, as less of the original material is weakened by alloying with the solder.

AUXILIARY SPRINGS

As pointed out previously, most dental structures are subject only to comparative analysis and not to exact quantitative analysis. This is not true in all cases, however, and auxiliary springs are one of the exceptions the quantitative analysis of which would seem to lead to worth-while results. Such an analysis has been made here for a few of these springs. The assumptions have been made that the diameter of the wire of this material is 0.02 in. and that the modulus of elasticity is 17,000,000 pounds per square inch. All stresses are presumed to be within the proportional limit.

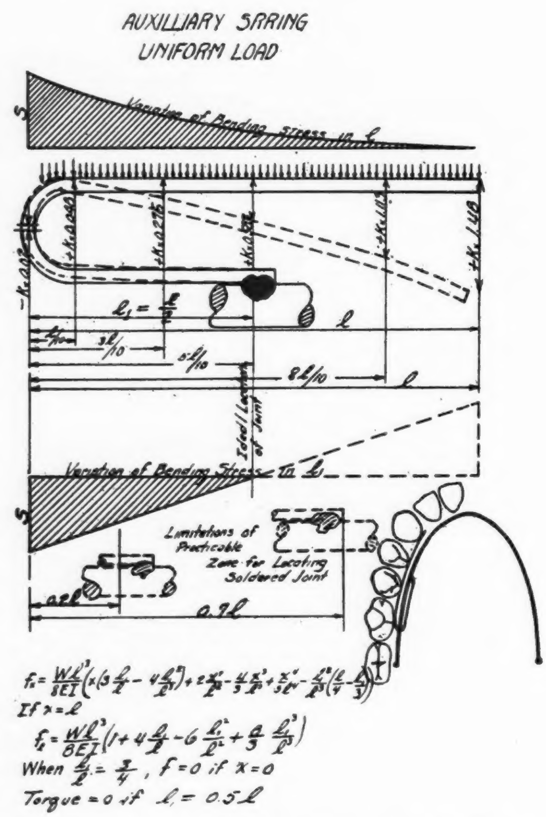

Fig. 5.—Showing the variation of stress and deformation of an auxiliary spring under uniform load.

Figs. 4, 5, and 6 show three cases of possible use of the auxiliary spring from the standpoint of loading and shaping. Fig. 4 shows the case of the spring used to move a single tooth as illustrated by the concentrated load at the free end. Fig. 5 shows the case of the spring used to move several teeth where the load is distributed over the length L. While actually the loading for this case would consist of a series of concentrated loads spaced the distance apart of the successive teeth, it has been assumed for the purposes of analysis that this load is uniformly distributed, and exceptions to this assumption are noted later. Fig. 6 shows the case of a doubly recurved spring used to move a single tooth.

Beneath each figure are shown formulas for the deflection or movement of the spring from its normal position under the influence of the load indicated. The first of these equations gives the deflection of the spring at any point X distance from the recurved end of the spring, and the second gives the deflection at the free end or point of the spring. Only the formula for

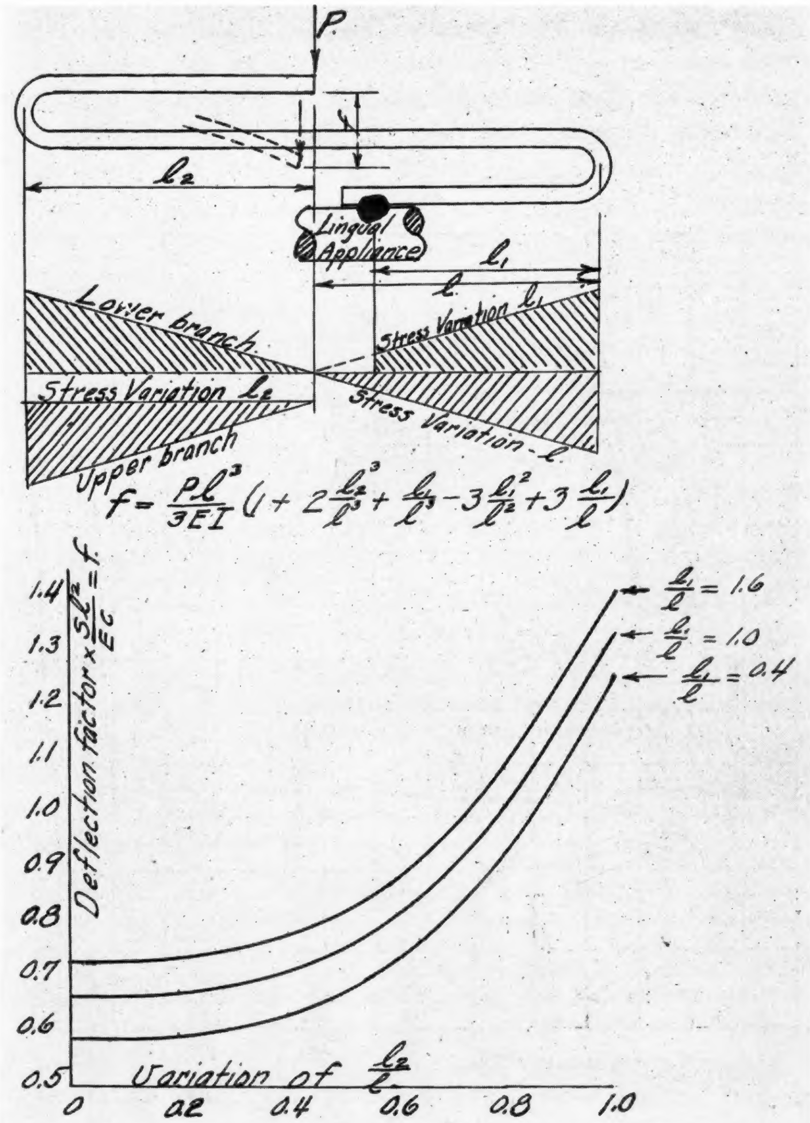

Fig. 6.—A partial analysis of doubly recurved orthodontia spring under a single load.

the movement of the free end is given in Fig. 6. No attempt is made here to show the method of arriving at these formulas. It will suffice to say that they are subject to experimental verification.

Above each figure in Figs. 4 and 5 is shown by diagram the variation of the stress due to bending in the free arm or length of the spring, which arm bears against the teeth. This bending is induced by the pressure of the tooth or teeth against the spring. Below each figure is shown the variation

of the stress due to bending in the length of the spring which is fixed to the lingual appliance. Variations of stress are also noted in Fig. 6.

Several practical conclusions result from these analyses. The cases shown in Figs. 4 and 5 will be first discussed. It will be noted that the maximum stress in the spring due to bending occurs at the recurved portion where L joins L_1. The stress due to bending at the soldered joint where L_1 joins the arch wire is less than this maximum in Fig. 3 for all values of L_1 greater than zero and less than 2L. It is equal to zero if L_1 is equal to L. In the case of Fig. 5 the stress at the soldered joint is less than the maximum for values of L_1 greater than zero and less than L, the zero when L_1 is equal to one-half of L.

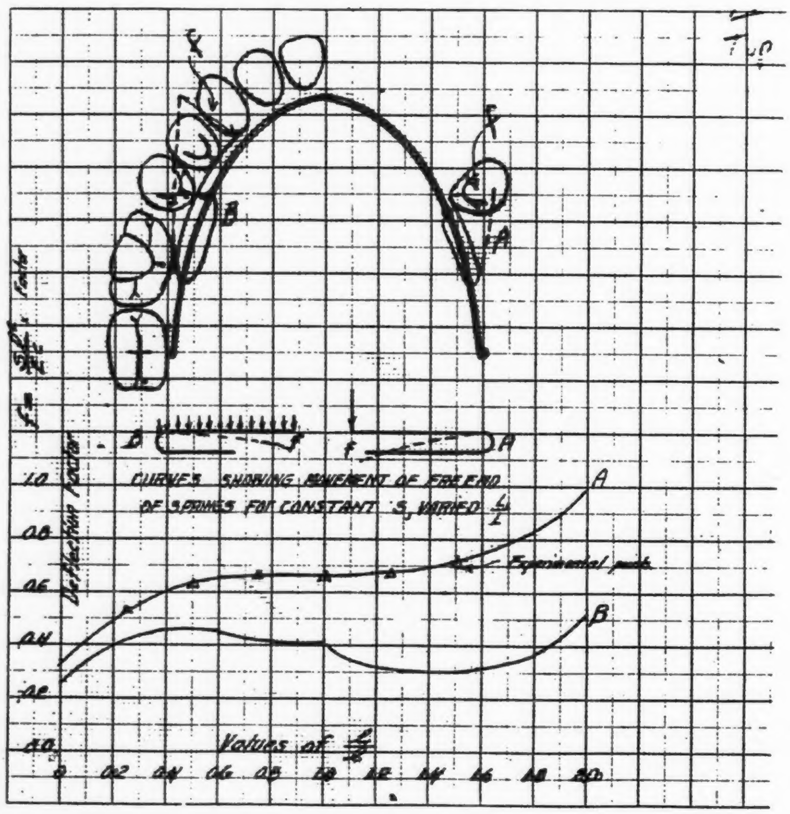

Fig. 7.—Showing the effect of varying the proportions of auxiliary springs on their permissible flexibility.

A study of the deflection formulas will show that in the case of Fig. 4 the deflection of the point of the spring is practically constant for values of L_1/L between 0.5 and 1, thus giving very little to choose from in this range as to flexibility under the primary load. It will be noted that the deflection of the heel of this spring is in the opposite direction to that of the point as indicated by the dotted lines for all values L_1/L between zero and 1.5.

In the case shown in Fig. 5 the deflection of the free end is also practically constant for values of L_1/L between 0.5 and 1 under the influence of the primary load. The recurved end of this spring also moves in the opposite

direction to that of the point when loaded for all values of L_1/L between 0. and 0.75. The comparative movements of the free ends of these springs for various ratios of L/L_1 are shown in Fig. 7.

In the case of the spring used to move a single tooth shown in Fig. 4, the fact that the recurved end of the spring moves in the opposite direction to that of the free end under the influence of the primary load has no particular significance. In the case of the spring used to move several teeth, however, it is important because it shows that it would be impossible to use such a spring to move teeth under a uniform pressure, since the two ends tend to move in opposite directions under this pressure. Such springs are used, however, for moving teeth in the same direction, and from these two facts we must conclude that in such cases the intensity of pressure on the teeth near the recurved end is greater than that on the teeth near the free end, while the possibilities of movement at the two points under a single adjustment of the spring are the reverse of this.

This increased intensity of pressure on the teeth near the recurved end of the spring, which is necessary in order that the teeth all move in the same direction, would tend to throw the point of zero stress for the soldered joint nearer the recurved end than is shown in the sketch. That is, zero stress occurs at the soldered joint when the ratio L_1/L is somewhat less than 0.5 in the practical case rather than when it is equal to 0.5 as shown in the sketch.

Fig. 6 shows the case of a doubly recurved spring under a single concentrated load in a manner similar to the method of illustrating for the other springs in Figs. 4, 5, and 7. No ratios of L_2/L greater than 1 have been shown here, nor have any greater ratios than 1.6 nor less ratios than 0.4 for L_1/L been shown. These limits of variation were chosen because they seemed to cover those used in actual practice. If we pass beyond them in the first case, we change the point of maximum stress, thus causing a break in the curve as in *B* of Fig. 7. If we pass beyond them in the second case, we shift the soldered joint to a point of dangerously high stress.

It will be noted that if L_2 becomes equal to zero in this case that the case reduces to that shown in Fig. 4 and in *A* of Fig. 7. It will also be noted that the deflection factor here is higher than those shown for the cases of Fig. 7. This would apparently lead to the conclusion that the spring shown in Fig. 6 is more flexible than that shown in *A* of Fig. 7. This conclusion, however, is a fallacy. The only fair method of comparison between the two springs is on the basis that they occupy the same space in the mouth. That means that the L of *A* in Fig. 7 must equal the quantity, $L_2 + L$, of Fig. 6. When corrections are made for this in the deflection factors of Fig. 6, so that they are in terms of overall length instead of as shown, the factors of Fig. 6 become less than the greatest of those shown in Fig. 7. In fact, I can see no real reason for the use of the doubly recurved spring by the orthodontist from the structural standpoint. It is not only less flexible than the singly recurved spring for the same space occupied but allows less leeway as to safe location of the soldered joint. In the case of the doubly recurved spring, the soldered joint should always remain reasonably near the point of application of the force for proper protection from undue stress.

The introduction of the recurved spring solved the difficulty of breakage at the soldered joint by placing the joint at a point of less than the maximum stress. It introduced a new difficulty, however, by placing a curved portion of the beam at the point of maximum stress. This difficulty arises due to the fact that in a curved beam the stresses are higher than they are in a straight beam subject to the same bending forces, and may under certain circumstances become equally as serious as the one solved.

This tendency in curved beams is illustrated in Fig. 8. In this figure the dashed line shows the way the stresses would vary across the face of the beam if it were straight, and the full line shows the manner of variation when it is curved under the same bending forces. It is seen from the sketch that the stress at the side of the beam nearest the center of curvature tends to be considerably greater than that which is normal for the straight beam. The table accompanying this sketch shows the values of S_1/S which approximately

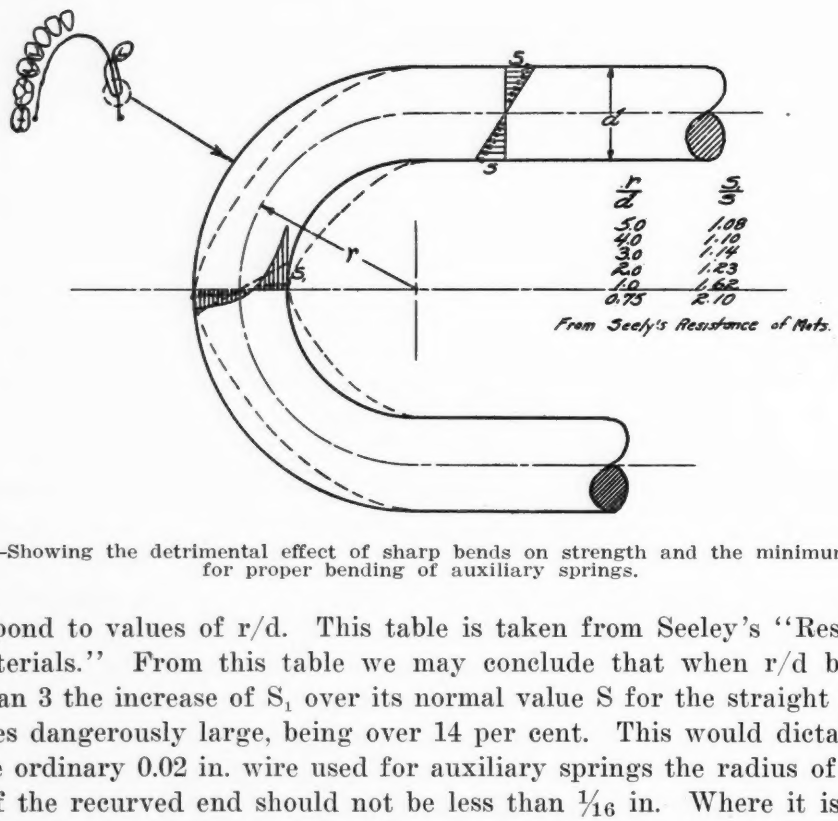

Fig. 8.—Showing the detrimental effect of sharp bends on strength and the minimum radius for proper bending of auxiliary springs.

correspond to values of r/d. This table is taken from Seeley's "Resistance of Materials." From this table we may conclude that when r/d becomes less than 3 the increase of S_1 over its normal value S for the straight section becomes dangerously large, being over 14 per cent. This would dictate that for the ordinary 0.02 in. wire used for auxiliary springs the radius of curvature of the recurved end should not be less than $\frac{1}{16}$ in. Where it is necessary to make the radius less than this, special provision should be made for that necessity by using the spring under a normal distortion smaller than usual so as to reduce the high stresses at the inside of the sharp curve. If the curved portion is not bent into a true circle as indicated by the dotted line in Fig. 8, too small a curvature may exist even though the distance apart of the two spring arms is equal to one-eighth inch. Bending the spring to curves other than a circle should be guarded against.

Table II shows the total pressure on the springs shown in Figs. 4 and 5, the total deflection of the free end of the spring under these pressures, and

the total torque exerted by the spring on the lingual appliance and so on the anchor teeth to which this appliance is attached for several lengths and variations of these springs. These tables are computed for springs made of 0.02 in. wire whose modulus of elasticity is assumed to be 17,000,000 pounds per square inch. It is also assumed in all cases that the maximum induced fiber stress is 100,000 pounds per square inch. While it is realized that this stress is too high for a working stress for most wires, it is a convenient round number for comparison, and values given may be scaled down in proportion for any practical application by multiplying them by the safe working stress for any particular wire and dividing by 100,000.

Table II with its figures is not included with the idea that the figures will have a great deal of value to the orthodontist as concrete quantities, although the work of Irish and an article by H. T. McKeag in the *Dental Record* for June, 1929, might lead one to suppose that there is an awakening interest among orthodontists in such figures. It is hoped, however, that these figures will serve as limiting values to orthodontists in the use of these springs.

For instance, the greatest permissible deflection shown in the tables for the 1.5 in. spring is less than 1 in. This spring is longer than the average

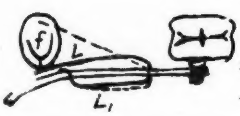

TABLE II

DEFLECTIONS, LOADS AND TORQUES IN AUXILIARY SPRINGS AT 100,000 LBS. SQ. IN. STRESS

	Values of L_1/L (See Figs. 4 & 5)					
	0.0	0.2	0.4	0.6	1.0	1.5
L = 0.5 Inch.						
Concentrated Load						
Defl. Ins.	0.049	0.072	0.087	0.095	0.098	0.104
Total Load, Oz.*	2.5	2.5	2.5	2.5	2.5	2.5
Torque, In. Oz.	1.25	1.0	0.75	0.5	0.0	– 0.625
Uniform Load						
Defl. Ins.	0.037	0.058	0.067	0.067	0.062	0.061
Lotal Load, Oz.*	5.04	5.04	5.04	5.04	5.04	3.36
Torque, In. Oz.	2.52	1.51	0.50	– 0.50	– 2.52	– 3.36
L = 1 Inch						
Concentrated Load						
Defl. Ins.	0.196	0.287	0.350	0.380	0.393	0.417
Total Load, Oz.	1.25	1.25	1.25	1.25	1.25	1.25
Torque, In. Oz.*	1.25	1.0	0.75	0.5	0.0	–0.625
Uniform Load						
Defl. Ins	0.147	0.233	0.266	0.266	0.246	0.245
Total Load, Oz.	2.52	2.52	2.52	2.52	2.52	1.68
Torque In. Oz.*	1.26	0.75	0.25	–0.25	–1.26	–1.68
L = 1.5 inches						
Concentrated Load						
Defl. Ins.	0.440	0.643	0.785	0.852	0.880	0.940
Total Load, Oz.	0.83	0.83	0.83	0.83	0.83	0.83
Torque, In. Oz.*	1.245	0.995	0.747	0.5	0.0	–0.625
Uniform Load						
Defl. Ins.	0.332	0.525	0.600	0.600	0.555	0.55
Total Load, Oz.	1.68	1.68	1.68	1.68	1.68	1.12
Torque, In. Oz.*	0.84	0.504	0.168	–0.168	–0.84	–1.12

*Avoirdupois.

perhaps, and the stress is too high for safety, yet I have seen orthodontists flex and incidentally overstress such springs more than this in demonstrating them, thus showing a lack of appreciation of their limitations. Such mishandling would not be thought of with large structures such as bridges and buildings and is detrimental to the tiny ones, such as the springs. Eventual failure of the spring due to such causes is very likely to be laid to faulty material when there is no realization that the spring has been mishandled in use.

The orthodontist who uses such springs in the mouth under a distortion out of the normal is liable very often to have stresses in his spring beyond the proportional limit when these service stresses are combined with the uncertain masticatory stresses which must exist.

A recommended safe value of the working stress in a spring would be about one-half the proportional limit. As an example of the use of this table, assume a spring made from wire the proportional limit of which is 120,000 lb. per square inch. The working stress is then 60,000 lb. per square inch. If the two arms of the spring are 1 in. long and equal to each other and the spring is to be used under a concentrated load for moving a single tooth, the permissible deflection is then from the table, 0.39 in., or say 0.4 in. at 100,000 lb. per square inch fiber stress. We wish to use only 60,000 lb. per square inch stress, however; therefore the permissible deflection will be $0.4 \times 0.6 = 0.24$ in. or say $\frac{1}{4}$ in. No greater deflection than this should be permitted in service under the primary load. The resulting tooth pressure will be $1.25 \times 0.6 = 0.750$ oz. from the table.

The following is a summary of the conclusions resulting from the foregoing analysis of auxiliary springs:

1. The movement of the point of the spring for either Fig. 4 or Fig. 5 is very nearly constant for values of L_1/L between 0.5 and 1.0.

2. The movement of the point of the spring is a reliable indicator of tooth pressure and stress in the spring.

3. The point of the spring and the recurved end move in opposite directions for values of L_1/L between 0.0 and 1.5 for the case shown in Fig. 4 and for values of L_1/L between 0.0 and 0.75 for the case shown in Fig. 5.

4. The fact that the ends of the spring move in opposite directions, under uniform load, forces the conclusion that the intensities of tooth pressure for the case shown in Fig. 5 are not uniform, but on the contrary are greater near the recurved end of the spring.

5. Conclusion 4 would place the position of zero bending stress at the soldered joint nearer the recurved end than is shown in Fig. 5.

6. For zero bending stress at the soldered joint the value of L_1/L should be 1 for the case shown in Fig. 4 and 0.5 for the case shown in Fig. 5.

7. In practical work L_1/L may range from 0.5 to 1.5 and still give the joint ample protection for the case shown in Fig. 4.

8. In practical work L_1/L may range from 0.2 to 0.7 and still give the joint ample protection for the case shown in Fig. 5.

9. The deflections, pressures and torques shown in Table II are somewhat above the safe values for continuous use of the spring when it is made of the very best wire. Not more than half of these values are safe for many grades of wire. The actual values may be found by multiplying values given by safe working stress and dividing by 100,000.

10. The doubly recurved spring shown in Fig. 6 has no advantage over the spring shown in Fig. 4 from the structural standpoint.

11. The spring of Fig. 6 is less flexible than that of Fig. 4 for a given space occupied in the mouth.

12. The soldered joint of Fig. 6 should be kept fairly close to the point of application of load for the proper protection from undue bending stresses.

13. The recurved end of the spring may be the cause of unduly high stresses by being bent to too sharp a curvature.

14. A value of less than 3.0 for r/d (Fig. 8) should not be used without specially favoring the spring by lightening its normal flexure in use.

15. Conclusion 14 would give a minimum allowable diameter at the recurved end of the spring of about 1/8 in. for the ordinary 0.02 in. wire.

In conclusion, I wish to express the hope that in touching upon these structural matters I have not laid myself open to the accusation of criticizing the orthodontist. That the orthodontist is amply capable of charting his own course no one is more aware than am I. It has been rather my desire to make the plea that dental material be required to bear only its fair share of blame for such failures as occur, and to point out that much blame for failures may be traceable to structural features which lie in a neglected field.

DISCUSSION

Mr. F. N. Menefee.—It was forcibly brought home to me that here was a profession in which materials are being used, both metallic and non-metallic, and that these materials are subject to forces just as materials are in other fields of human endeavor and that the forces distort the material and produce stresses according to the same basic laws that the engineer has used in his structural design for many years. This suggested analogous situations which are coming up all the time in our everyday life concerning the application of old or at least previously known ideas to new uses.

Mathematics was at one time more of a diversion for the intellectually curious than an absolutely necessary tool without which present-day civilization would not be maintained. I dare say that the first person to apply calculus to the insurance business encountered at least mild surprise, and we all know that chemistry and food existed side by side long before it was discovered that there was a 100 per cent connection between metabolism and chemistry.

It may seem a bit strange and extravagant to say that many of the laws of nature discovered by physicists and used by the engineers in designing bridges and skyscrapers, tunnels and roadways can be made use of in designing bridges for teeth, but reflection on the matter merely brings out the question, why not, in a matter-of-fact way.

We use the same laws of mechanics to compute gear trains in a wrist watch as are used in the mightiest rock crusher. The fundamental principles which govern the selection and dimensioning of materials for the huge compound locomotive are the same as those selected for the most delicate machine. So from the standpoint of one trained in these principles and in the behavior of materials under external forces we find that the difference is largely a matter of degree.

A few years ago I was pleasantly shocked to learn that the Dental College at the University of Michigan had a testing laboratory almost as complete as that one known as

the Materials Testing Laboratory in the colleges of engineering and architecture. To be sure, the machines for searching out the quality in the various materials under consideration are smaller and more delicate, but otherwise identical. There are tension, compression, fatigue, hardness, and many others designed to measure for the orthodontist the various service requirements of his materials, along exactly the same lines that the engineer employs in determining the same qualities in the materials going into bridges, machines, tools, or roadways. And of course the mathematical theory of elasticity applies to your structures as well as to the engineer's. Not long ago a sheet metal alloy of aluminum was brought to the engineering laboratory of the University of Michigan for a fatigue test. The metal was to be used in dirigible construction. Our fatigue machines were too heavy to have the required sensitiveness, but we found just the right machine in the testing laboratory of Dr. Marcus Ward, dean of the College of Dentistry. With but a comparatively slight acquaintance with the technic of your profession it seems reasonable to predict that you have entered into a field of study that will grow in magnitude and usefulness to mankind.

A few years ago we had a student of dentistry who took special mechanics of materials courses in the engineering college, and we now have a graduate chemical engineer enrolled in the Dental College studying for his doctor's degree. He is taking all the courses in mechanics and strength of materials to prepare himself for this special service to the orthodontist. We have more calls for men with this training for the engineering field than we can supply, and it seems reasonable to expect that with modifications the same will become true in the field of orthodontia.

The laws of elasticity of material employed by Prof. Brumfield are largely based on the fact that most materials are elastic up to a certain intensity of internal stress, after which they are both elastic and plastic. By elastic we mean that the material will deform under external load and return to its original dimensions when the load is removed. In effect this means that the material deforms, i.e., elongates under tension or shortens under compression, but that it is continually resisting the external force whatever it is, and that it continuously strives to regain its original dimensions and will do so immediately the force is removed. Fortunately this law is rather simple in that the deformation is proportional to the load, or put in another way, the deformation of a unit of length is proportional to the unit stress or unit internal resistance to the external load.

Every material possesses its own ratio of stress to corresponding unit deformation. We call this Young's Modulus of Elasticity. In steel the ratio is about 30,000,000, in cast iron 18,000,000, and wood about 2,000,000. The gold and gold alloys dealt with in Prof. Brumfield's treatise have a ratio from 14,500,000 to 18,000,000. The fact that each material has some constant ratio of stress to deformation is known as Hooke's Law and may be graphically pictured by plotting the results of a physical test. This is done by considering the vertical ordinates on squared cross-section paper as stress in pounds per square inch and the horizontal distances as deformation in inches per unit of length of the test specimen. By changing the vertical scale on Prof. Brumfield's Fig. 3 so that it gives the load in pounds per square inch instead of total load, we would have such a plotting. In elastic materials a straight line will result, up to the limit of elasticity of the material; and by referring to the diagram one may pick out a certain stress on the diagram and at once pick out the corresponding amount of deformation of an inch of the material from the horizontal base line. One-half the stress chosen will show a deformation of one-half that previously found. This proportionality is constant up to the limit of elasticity. There the proportionality ceases, for the material then gives up the fight and permanently deforms. In all work involving the use of material where dimensions and form are to be kept constant, we must know the limit to which a material may be deformed without exceeding this limit of elasticity or of proportionality in behavior between stress and strain or deformation. The stress divided by the corresponding unit deformation is called the modulus of elasticity.

If a pencil is bent, we all know that one side is in tension and the opposite in compression. So with all other materials, including the gold under consideration. If we had a way of actually measuring the elongation per inch on the tension side, we could compute the stress, if we had a stress deformation curve such as already mentioned. It is not always

easy to measure the deformation or elongation of the fibers on the tension side, but by mathematics we can compute the stress or elongation of the tension fibers provided we know the deflection.

A complete demonstration of the various ways in which this fundamental law of mechanics of materials operates is not permissible in this discussion, but that it is true and accurate is demonstrated every day in testing laboratories and in engineering structures throughout the world.

In many cases, of course, the material is bent considerably beyond the elastic limit and remains permanently deformed. If one wants a visual manifestation of material stressed beyond the elastic or proportional limit, it is only necessary to remember that if wire is bent and remains bent the stress produced by bending was beyond proportional limit.

Prof. Brumfield's premises, reasoning, and conclusions are sound relative to his treatise on the strength of the various grades and sizes of wire. The foundation upon which he builds may not be familiar to all, and yet it is thought that many will be able to use the tabular results to advantage.

It may be a little easier to discuss the flexure phase of his paper, and in a qualitative way at least, illustrate his formula. He starts with $f = \frac{C\ Pa^2}{Ed}$. For the time being, neglect the C and consider the remainder. Assume a beam, such as you are familiar with, it may be of springboard type, fastened at one end, free at the other, which is called a cantilever; or it may be a plank spanning a creek at the country club, either fixed or free to move at the ends. If free it is called a simple beam, if not it is called a beam with fixed ends. But any one of the three types is sufficiently impressed on the minds of all persons to warrant referring the reader to it if it will assist in making clear the question before us.

P is the load on the beam, choose your own beam, do not move the load, i.e., keep all conditions the same, but double the load and you will double the deflection. Now start again. You have your beam or plank with its load in mind, and you know it is doing some deflecting; you can see it. Keep everything the same but double the length and you will quadruple the deflection. Or make no changes in load and length but double the depth and you would stiffen the beam at once and decrease its deflection to one-half of its former value. For any one material, C and E are both constants of such magnitude that when they enter in the combination of terms in the formula some finite deflection takes place, such as we have all experienced, and that deflection will change according to the manner above referred to, or it will change with a change in P, a, or d, and the law is as applicable to beams of wire used by the orthodontist as it is to beams of greater size and different material, for the change in deflection resulting from a change in materials is taken care of by E and the change in size by a^2 and d.

Very probably the orthodontist has had the experience of using material that functioned satisfactorily for a while and then broke. The small amount of space into which his structure must be placed naturally causes him to choose the smallest wire he feels will produce the desired result and at the same time last permanently. The failure of the material means that the duty placed on it produced a stress beyond the proportional limit and that very likely an additional stress with corresponding strain is imposed every time the subject brings his teeth together in mastication. Under such conditions one of two things will happen, the material will break or will permanently deform. If the first, the uselessness of the structure is obvious; if the latter, it may be just as useless, though not so evident, for while the structure is still intact and to the eye may look the same, it will not exert the pressure intended, because of the fact that it is permanently bent out of its intended shape or it has permanently elongated.

If the orthodontist can get a smaller wire to do the work of a larger wire, he will in many cases choose it. The engineer does it in bridges and machinery—the orthodontist to save space and the engineer to save space or to lighten the dead load of his structure. But both do it by using a material which may be stressed to greater amounts by reason of a higher proportional limit. But in either case, if the structure is one which performs the duty imposed upon it, by its resistance to bending, the laws of elasticity of materials used by Prof. Brumfield must be resorted to if like results are wanted of material of different

dimensions or different resistant qualities. When a wire of known physical properties and in a certain type of structure is properly functioning, a smaller wire should only be substituted after consulting the tables prepared by Prof. Brumfield.

Generally speaking, the maximum stress on the various types of springs, such as those shown in Dr. Oren A. Oliver's paper on "The Technic of the Lingual and Labial Arches," comes at some one point. Prof. Brumfield has illustrated this in the conventional manner in Figs. 3 and 4 at the loop end of the spring and has designated it as S.

Undoubtedly these springs are bent cold. If so, they have already been stressed beyond the proportional limit at the loop, for they remain bent or deformed out of their original contour. We have all had the experience of breaking wire by bending it in this manner, and then working the free end back and forth a few times. This procedure stretches the outer fibers of the loop beyond their capacity to return to their original length. Very probably the innermost fiber is shortened by compression a like amount. Photomicrographs would show the grains to be elongated in the one case and flattened in the other with some readjustment of position by sliding on each other along the grain boundary.

Once the bend or loop is made the material is damaged at the loop and subsequent deflections back and forth as the structure is put in service in mastication of food may gradually destroy the coherence of the grains along their boundaries and failure results. This is sometimes called fatigue. In Dr. Oliver's paper he speaks of removing "the temper from the locks by heating them and plunging in cold water." Heating the bent wire to the proper temperature removes the strain or distorted condition of the grain and the attendant internal stress, and promotes resistance to fatigue. Plunging in cold·water probably corresponds to what is known as quenching on engineering materials. While heating of sufficient amount restores the material to an unstressed and unstrained condition, it is generally accompanied by a softening and lowering of the proportional limit. Quenching in cold water from the heated condition with subsequent reheating and slow cooling hardens and restores the high proportional limit, leaving the bent portion of the structure in an unstressed and unstrained condition until further distortion or bending takes place in service. After this the structure then follows the laws of elasticity as set forth by Prof. Brumfield.

Referring to Prof. Brumfield's treatment of the ability of a structure to absorb the energy of a moving force, it may be said that we are not as sure of our ground as we are when dealing with static or gradually applied loads. For the gradually applied load we are certain of our formulas for stress and deflection as we are of the value of E or modulus of elasticity. The formulas have been checked many times and are commonplace to the engineer, although their application to orthodontia is new.

The trouble is not that we are uncertain of the energy of the dynamic force. It can be expressed exactly, but an expression of the stress effect produced in the dissipation of a dynamic force is difficult if not impossible to express in a practical way. The trouble lies in the variability of elasticity of the material which absorbs the energy. Knowing the energy of the active force and the distance it travels after it comes in contact with the medium which must absorb it, we can equate the energy to an average resistance times the distance required to stop it. But this only gives us the average external force on the absorbing medium, whereas we are more interested in the maximum force, or to probably correct hypothesis, that the more accurately we know the maximum external force, the more likely we are to be able to solve the maximum stress resistance necessary to dissipate the external force.

So we have to resort to assumptions, and our assumptions cannot possibly be correct for more than one set of circumstances and probably not always for them. For instance, I might strike the end of a springboard with a hammer hard enough and swiftly enough to drive the hammer head through the plank. If we had a way to measure the deceleration of the hammer head as it passed through the board, we would be able to compute its force; but that force would not cause the deflection that a static force of the same magnitude would cause, nor would the compressive and tensile stresses in the board be the same at its junction with the dock. They would not be the same because the bending would not be the same. Tension and compression due to loads causing bending are due directly to the bending, indirectly to the load.

In the illustration the resisting stress was localized at the points of application where the hammer had caused the destruction. Undoubtedly no violation of the natural law, "energy spent by the resisting medium equals that spent by the acting or aggressive medium," took place. But what took place was too sudden to come within the scope of our formulas which very accurately give us internal stresses due to gradual or static external loading.

Stress travels only as fast as deformation takes place. If a load on a wire could be instantaneous, it would probably produce an infinite stress, although we have a formula to the effect that instantaneously applied loads double the static stress. The formula is not much used and is wrong in that several factors entering into the problem are left out, and then the attainment of an instantaneous force is a practical impossibility.

Suddenly applied loads or forces undoubtedly do demand increased internal stress resistance, that internal stress resistance increasing indirectly as the amount of material brought into play in the resisting medium is decreased. The more sudden the external force, the less time the resisting medium has to communicate to the surrounding material and thus to shift part of its burden, for stress travels through different media on distinctly different time schedules, and if the demands of the external forces are such as to excel the natural rate of stress communication to surrounding parts of the resisting medium, local failure takes place.

A grand stand may hold 50,000 people. If they file in through properly constructed gates, all is well. If they all demanded instantaneous admission to the gate, we would have what college students call crashing the gate.

We know what static loading is and most of us could come to an agreement on gradually applied loading, but sudden loading is not a quantitative description of loading, and a quantitative description of resisting stress will not come out of it.

Fortunately most of the sudden and what the engineer might call impact forces with which the orthodontist attempts to cope are self-inflicted, and the subject is careful to apply them in a way that we would all agree is gradual, thus bringing them within the scope of the formulas presented by Prof. Brumfield. His injunction to keep well below the proportional limit of the material is good. It is the common practice of engineers; the difference is that we generally know the external loads on our structure and can compute our resulting internal stress, while the orthodontist is handicapped by lack of certainty as to external load or force and by a shape of structure which does not as readily lend itself to stress computation even though the external forces are known. Except where the deflection can be measured, this requires a trial and error or cut and try procedure until a satisfactory structure results, from that time on relative external forces or load carrying capacities and deflections may very accurately be obtained through Prof. Brumfield's ingenious tables.

THE TREND OF ORTHODONTIC TREATMENT*

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THE problem of orthodontic care and treatment has not yet been completely solved. In the discussion of the trend of orthodontic treatment one can, I believe, present the subject more intelligently by building the present upon the foundation of the past. Such a background is quite necessary if we are to come into a full understanding of the present status. The unfolding of our problems has been slow and tedious, and the orthodontist of today is still confronted with many of the same problems with which his predecessors had to contend. The creation, accumulation, and classification of knowledge pertinent to orthodontic practice, by which a more comprehensive treatment is possible, cannot be attributed to any one man or to any particular group of men. Contributions have been made by various men over a period of many years. Some of the principles enunciated in the teachings of Fanchard back in the eighteenth century are still basic To any thinking person it is perfectly obvious that the science of orthodontics has reached its present state of excellence by a gradual constructive evolutionary process. The person only deceives himself who feigns to believe that modern orthodontics sprung spontaneously out of a deep dark abyss of an orthodontic world.

There is abundant evidence in the history of orthodontia to prove that its development has been dependent upon and subjected to conditions which have been analogous to those encountered in the development of other specialties of dentistry and medicine. It is true that during certain periods of our existence, men have risen far above the average to impress themselves indelibly upon the history of the achievements in orthodontia. The deeds and accomplishments of these men mark important epochs, and their contributions have largely laid the foundation upon which the present superstructure has been built. They were driving sincerely, and in most part with great wisdom, toward a constructive development of our specialty. Notwithstanding this fact, however, the specialty probably would not have survived had it not been for the invaluable assistance rendered by those who may be termed the lesser lights. Sometimes their pooled strength was sufficiently potent to impress their will upon the leaders so profoundly that they were not infrequently forced to engage in new technical skirmishes and maneuvers in the hope that advantageous positions might again be attained. Whenever this occurred, it resulted in clearer thinking, better reasoning, and a closer and more careful study and application of fundamental principles, out of which there evolved a better understanding of orthodontic problems. So progress and efficient practice gradually supplanted speculation and archaic methods.

In a discussion of the trend of orthodontic treatment, we are immediately

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confronted with the problem of what constitutes a trend. Briefly defined, it is an inclination in a particular direction. Upon what premise then are deductions to be made or conclusions to be based? It would not only be unfair but decidedly unjust for me to discuss this question in the absence of documentary evidence other than in a hypothetical manner.

Are we to understand that the trend is established by the application of principles advanced by certain men or certain groups of men, and which in the past have been erroneously termed systems? Or is it established by the employment generally of the various so-called methods by a much larger group? Or is it determined by a similarity of practice by a large majority?

I seriously doubt whether all of us can come into complete agreement with respect to these things. In matters pertaining to municipal, state or national affairs, public opinion and influence will ultimately become the deciding factor, but a scientific proposition is quite a different matter. It is claimed, or at least assumed, that orthodontics has finally reached the stage where it can justifiably be called a science. It is, in any event, a distinct specialty. Science is exact, organized, and classified knowledge. Knowledge denotes acquaintance with or clear perception of facts. Information is knowledge communicated or acquired (Webster).

Now, then, may I be presumptuous enough to ask whether or not orthodontics is being practiced generally upon the basis of a scientific specialty, or is it being practiced largely upon the basis of placing appliances upon the teeth without regard to knowledge derived through observation and investigation, and the information disseminated through numerous channels? These are questions which at the present moment, to my mind at least, are difficult to answer.

Let us now consider briefly some of the events which have led up to our present condition. It is quite unnecessary to enumerate the many constructive contributions that were made during the early stages of the development of orthodontia by such outstanding men as Fauchard, Schange, Harris, Coffin, and many others. It is needless to say that their devotion to the work and accomplishments in this field wielded a mighty influence in the prespecialization period of our existence. Their work consisted chiefly in designing appliances for the purpose of moving malposed teeth into alignment. The primary object of such service was to improve the appearance; the question of conservation or function was given little, if any, thought or consideration. The biologic aspect of orthodontia had not yet been given much study or attention, and the trend might properly be defined as being almost, if not altogether, mechanical.

In the next epoch which may be concluded at the end of the nineteenth century, let us delineate some of the more important points in the work of Kingsley, Farrar, Guilford, Jackson, Case, and Angle. It was during this period that a great evolutionary process began. A clearer conception of orthodontic problems was gained principally through the careful study and application of fundamental principles by these men.

Considering the situation during this period from a purely orthodontic viewpoint and assuming that the teaching of these men and their contempora-

ries exerted an influence of considerable moment, we find that the trend of treatment was modified so as to include some phases of the biologic side. It is quite certain that the importance of this aspect was becoming recognized to a much greater degree. Evidence of this fact is displayed in the publications of practically all of the leading men of this period. This clearly demonstrates that the problem of malocclusions was being considered from a standpoint other than just moving the teeth into alignment with mechanical devices.

The following excerpts from Kingsley's *Oral Deformities* published in 1880 are interesting: "Symmetry and harmony do not imply uniformity and the dental arch may be developed up to the highest type of perfection, and yet there exist as great a variety of form as there would be in the faces of the aggregated beauties of the world; races, nations and families are thus represented without deformity." Further, "Much of the success in treating irregularities will depend upon a correct diagnosis and prognosis. This is one of the most difficult problems in the practice of dentistry, and its proper performance must take into consideration the efficiency of the masticating apparatus, the organism of the teeth, the ravages of decays, the family type and the relation of the features; the constitution, temperament, and the systemic conditions of the patient, the sex, age, and social status, the causes of displacement whether accidental, congenital or hereditary. The means and appliances for correction, the time, trouble, and skill of the operator, and the time, annoyance and endurance of the patient, the risk of inflammation and of destruction of pulps; and finally, the character and permanency of the change wrought." He further states, "different opinions are held as to the kind of pressure most in accordance with physiological action; some maintaining that the pressure must be constant and uninterrupted, while others claim that interrupted pressure will produce the most beneficent result. I doubt if either can be shown to be the best in all cases. It would be difficult to make a test of the different methods with any accuracy, as the coincident but unknown factors might not be the same." And further, in the discussion of appliances he writes, "To the anatomical, physiological and pathological knowledge required of the operator, there must be added a knowledge of mechanics and a clearness of perception and ingenuity to apply it. Precisely the same ability is required as would be demanded of a mechanical engineer in the construction of a machine for a given purpose. He is to apply directly one of the mechanical powers, or to invent a combination of those powers as will best answer the purpose. Levers, pulleys, inclined planes, wedges and screws are all at his command; and it is quite as impossible to describe an apparatus, such as would be applicable to every case, as it would to anticipate the future and describe every invention that the fertile mind of man may make for his comfort or convenience."

Dr. Kingsley after a careful and rather exhaustive study of malocclusions came to recognize that their correction involved many difficult and complex problems. Since he was a man possessed of exceptional qualities, indomitable courage, fine intellect and sound judgment, his deductions and conclusions were readily accepted by the profession and wielded a broad influence in directing the trend of orthodontic study and treatment. His work also served

as an inspiration to others to make a closer study of orthodontics, and in reviewing it one is strongly impressed with the fact that much of the present-day discussion is closely allied to his conception and teaching. In all his writing he emphasizes those things which pertain to the biologic side, but in doing so he does not minimize the necessity for efficient, well constructed and properly placed appliances.

Dr. J. N. Farrar in an article published in *Dental Cosmos* in 1876, entitled "An Inquiry Into Physiological and Pathological Changes in Animal Tissues in Regulating Teeth" reported the following conclusions:

First, that in regulating teeth the traction must be intermittent and must not exceed certain fixed limits.

Second, that while the system of moving teeth by elastic rubber apparatus is unscientific, leads to pain and inflammation, and is dangerous to the future usefulness of the teeth operated upon, a properly constructed metallic apparatus, operated by screws and nuts, produces happy results, without pain or nervous exhaustion.

Third, that if the teeth are moved through the gums and alveolar process about one two hundred fortieth ($\frac{1}{240}$) of an inch every morning, and the same in the evening, no pain or nervous exhaustion follows.

Fourth, that while these tissues will allow of an advancement of a tooth at this rate ($\frac{1}{240}$ of an inch) twice in twenty-four hours, the changes being physiologic, yet, if a much greater pressure be made, tissue changes will become pathologic.

He further gives this law: "In regulating teeth, the dividing line between the production of physiological and pathological changes in the tissues of the jaw is found to lie within a movement of the teeth acted upon, allowing a variation which will cover all cases, not exceeding one two hundred fortieth ($\frac{1}{240}$) or one one hundred sixtieth ($\frac{1}{160}$) of an inch every twelve hours."

In an article published in the *Dental Cosmos* in 1878 entitled "Regulation of Teeth Made Easy by the Positive System" he states:

"The entire practice of regulating teeth may be summed up under the following aphorisms or fundamental rules for constructing and operating mechanical appliances.

"First, all mechanical appliances for regulating teeth should, if possible, be constructed upon the principle of the screw and inclined plane.

"Second, all apparatus for regulating teeth should be constructed with the view of being worn inside the mouth.

"Third, all mechanical appliances should be so constructed as to cause as little pain and inconvenience to the patient in speech and eating as possible.

"Fourth, all mechanical appliances should be constructed as minute and delicately as possible, and be capable of doing the work with certainty and effect.

"Fifth, all appliances should be constructed so that the patient can with a little instruction do most of the work by means of keys to turn the screws and nuts."

Dr. Farrar published a series of articles in the *Dental Cosmos* from 1876 to 1885, in which he covered many phases of orthodontia, but more particu-

larly the mechanical side which he termed the fundamental principles of the positive system of regulating teeth. His book on *Irregularities of the Teeth* was published in 1888 and was a summation of most of his work. It is devoted largely to the description and use of mechanical devices. Dr. Farrar was almost a genius, his talents were manifold and his contributions constructive. He was among the prominent men of his time. His opinions were respected and he exerted a broad influence in directing the trend of orthodontic treatment.

In the year 1898, Dr. Guilford had the third edition of his book *Orthodontia* published. On the first page of the preface he states that "owing to the rapid strides in both the science and art of this branch of dental practice, the author in preparing the third edition of his work, has taken advantage of the opportunity thus afforded to introduce many changes and improvements. Every chapter has been more or less changed to conform to present knowledge and three new chapters introduced. One of these 'Dynamics of Tooth Movement' together with the introduction of many new and etymological correct terms will, it is believed, add to the scientific value of the work." Dr. Guilford devotes about three-fourths of the space to the description and use of mechanical devices and the other to the biologic phase, included in which there is a chapter on the rules governing extraction of teeth as related to orthodontia. Eight definite rules are proposed and explained. He states, "Probably no operation in the practice of orthodontia is more important, or has associated with it more possibilities for good or evil to the patient than that of extraction. As related to the prevention or correction of irregularity, extraction on the one hand may be of the greatest possible benefit, or on the other it may result in irreparable injury. Judicious extraction, if undertaken in time, will often forestall or prevent an irregular condition of the teeth, and in other cases it will assist greatly in simplifying the operation of correction. Occasionally it is all that is called for on our part, nature performing the rest of the operation unaided."

Dr. Guilford was a man of sound judgment, considerable intellectual capacity, a pleasing personality, dean of a school of dentistry in which he was professor of orthodontia. He was a good administrator, a fluent speaker, and considered an authority in subjects other than orthodontia. His advice and counsel were often sought and his opinions well received. He had many contacts with dentists, so his influence had a wide range with quite a definite effect on the trend of orthodontic treatment.

While Dr. V. H. Jackson's book, entitled *Orthodontia and Orthopaedia of the Face,* was not published until 1904, it represented a compilation of his work previous to 1900. In it he devotes about five-sixths of the space to the mechanical phase and the other one-sixth to what may be termed the biologic. One chapter of two pages is used to describe occlusion, while another of five pages is allocated to the extraction of teeth for relieving irregularities. Under the history of the case he states: "It is essential that a correct diagnosis of the condition should be arrived at before beginning an operation and if the case is a complicated one, it is usually necessary to have a knowledge of the hereditary proclivities, such information should be gained from the parent or

guardian. It should state the age, whether the patient has any bad habits, such as sucking the cheek, tongue, lip, fingers or thumb, and how long continued, or only during the hours of sleep, or when suffering from colds; and any other points that may seem to be necessary for obtaining a complete understanding of the case, and that the physical examination should consist of, first, examination of the mouth; second, examination of the throat and posterior nares, and third, examination of the nose.

Dr. Jackson undoubtedly through a long experience became cognizant of the fact that not infrequently failures resulted from a lack of understanding of cause and effect. His work consisted chiefly in developing the removable appliance which he dubbed "Jackson's system of correcting irregularities of the teeth." He was endowed with indomitable courage, unwearied enthusiasm, and a persistence beyond comment. Dr. Jackson presented the principles and technic of the removable appliance before many societies and carried with him a large display of models and appliances which he kept on display almost continuously. He believed so thoroughly and conscientiously in the applicability and efficiency of this appliance that his arguments as to its relative merits were uncompromising. Through the forcefulness of his presentations, the logic of his arguments, and the generous and courteous manner in which he gave of his time and knowledge to any who were interested, he enlisted a large number of followers among the dentists who adopted his plan of treatment.

Drs. Jackson, Case, and Angle came into the picture about the same time, the latter part of this period. They were always vying with each other, each attempting to excel, and each promoting his own system.

Dr. Jackson clung exclusively to the removable appliance and made it possible for those who were interested enough to receive instructions from him in its construction and use.

Dr. Case developed an extensive and complicated system of mechanical devices and believed that the dentist should possess enough technical skill and have sufficient physical equipment in his office to construct the appliances for the cases which he desired to treat.

Dr. Angle believed in the simplification and standardization of appliances. He developed the Angle system and had placed upon the market, standardized sets of Angle appliances for correcting irregularities of the teeth.

Dr. Case and Dr. Angle were diametrically opposed to each other's views in many respects. They were both becoming prominent in the field of orthodontia, and each was exerting a big influence in the trend of treatment. The two most vital points of contention between them seemed to be that Dr. Case believed that the correction of facial deformities was primary and occlusion of the teeth secondary. That is to say, that the best results of most cases that would fall in classes two and three Angle classification, so far as the facial balance was concerned, could be obtained by the extraction of teeth, and further, that the operator should have a large assortment of appliances at his command.

Dr. Angle believed that occlusion was primary and facial balance secondary. To be more explicit, that most facial deformities could best be cor-

rected by retaining the full complement of teeth and placing them in correct occlusal relationships, and further, that a limited number of standardized appliances made to machine accuracy and sold to the operator through the supply houses was the most efficient and a more practical method.

Dr. Angle states in this seventh edition of *Malocclusions of the Teeth,* page 62, "We believe there is a law for determining the best balance of the features, or at least the best balance of the mouth with the rest of the features, which artists probably know nothing of, and one which for our work is far more unvarying and more reliable than even the judgment of the favored few. It is, furthermore, a law so plain and so simple that all can understand and apply it. It is that the best balance, the best harmony, the best proportions of the mouth in its relation to the other features require that there shall be a full complement of teeth, and that each tooth shall be made to occupy its normal position—normal occlusion."

Dr. Case states in his book *Dental Orthopedia,* page 131, under the heading "The Author's Teaching," "The author has endeavored to make this so-called 'modern teaching' [this has reference to Angle's teaching], authentically plain, before proceeding to point out his reasons for believing that in its principal mandates it is a false teaching, which if indulged in by any considerable portion of the profession, it cannot help but retard the science of orthopedic dentistry. It will be observed in this teaching that the standard of dental perfection is normal occlusion, which is claimed is 'incompatible with abnormal facial outlines.' In the author's practice and teaching, the standard of dental perfection is 'Dento-Facial Harmony' or 'Normal Dento-Facial Relation,' which in the correction of irregularities includes 'normal occlusion' whenever the presence of all the teeth is demanded; but always an occlusion whose cusps interlock or interdigitate, else function and retention would not be assured."

It is probably true, if one is to judge from a review of the literature, that the most outstanding accomplishments of these two men at this time was in the development of orthodontic appliances. No doubt they utilized the biologic knowledge which preceded them in a way to serve their purpose best, but their chief efforts were directed toward the perfection and use of mechanical devices.

To Dr. Case must go the credit for designing and constructing many types of appliances. He devoted much time and attention to the dynamics of tooth movement. His appliance for root movement, though complicated, was the most efficient of the time. He made a careful study of facial art as related to orthodontia, and his practice was based largely upon this premise. Dr. Case was possessed with many fine qualities. He had a large intellectual capacity, a clear and judicial mind, honesty of purpose, was kind, generous and considerate, and was blessed with a charming personality. Because of these attainments and his many contributions in the field of orthodontia, he made hosts of friends in the dental profession. His influence upon the trend of orthodontic treatment would have been very great had his work been systematized so that it could have been taught to others in a comprehensive and orderly manner. His influence upon the advancement of orthodontia, upon

elevating its standards of practice and its segregation as a special branch, was indeed very definitely felt.

Dr. Angle must be given credit for possessing an uncanny ability to select and coordinate those things which were of value in the practice of orthodontics. His work was becoming recognized as having unusual merit. By designing a system of appliances which were efficient and practical, and by providing a convenient channel for the dentists to purchase them through the dental supply houses, his methods began almost immediately to take the ascendency.

Dr. Case made this statement in presenting a paper before the Michigan State Dental Society in August, 1891,* "The Angle system of regulating by means of screws so arranged as to produce the desired movements with certainty and exactness, by manipulating at intervals the screws, is the most definite and scientific method of changing positions of teeth known."

Dr. Angle's conception and application of occlusion, his uncompromising attitude toward the extraction of teeth, his high ideals, fine technical skill, courage of conviction, inflexible personality, and lofty aims stamped him as a powerful figure in the realm of orthodontia.

I have selected these men from whom to quote because, I believe, they were the most prominent in the field of orthodontia and were in possession of the best knowledge of the day and, therefore, exerted a strong influence in establishing the trend of treatment. While they often disagreed with respect to various methods and frequently assumed an uncompromising attitude toward the use of certain types of appliance, they were always striving to improve conditions by advancing the science of orthodontia.

One may fairly conclude, I think, that the twentieth century was ushered in with orthodontic treatment based at least in a general way upon the following conditions:

1. The biologic problems were relegated to a place of secondary importance.
2. The study of occlusion was given but meager attention.
3. The extraction of teeth was generally recommended.
4. Prevention was largely ignored.
5. Treatment was seldom begun until after the full complement of teeth had erupted (except the third molars).
6. Esthetics was the primary object of treatment.
7. The mechanical phase was the most important and was given by far the greater consideration.
8. "Systems" of treatment of individual men were being strongly promoted and recommended usually to the exclusion of all other methods.
9. Orthodontia was given a small place in the curricula of schools of dentistry and its teaching was considered of minor importance.
10. There were no graduate courses or extension courses of study provided in any of the schools, nor were there any private schools of orthodontia.

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*Dental Register, 1892.

11. Standardized appliances were on sale at dental supply houses accompanied with instructions entirely inadequate for their intelligent use.

12. Many persons were attempting to correct malocclusions without having the least conception of the principles involved.

The opening of the Angle school in St. Louis in 1900 for teaching orthodontia marked a most important epoch in our history. Very shortly law and order was to supplant chaos. A vast number of conflicting ideas were coordinated. Archaic methods were eliminated. Orthodontic knowledge was gathered and classified, and fundamental principles were promulgated. In fact, orthodontia was reborn. During this transitional period there came into being, what some were pleased to term, the new school of orthodontia. While I do not believe that this was to include only those within a certain group, such was the interpretation generally made. At any rate under this influence, orthodontia progressed rapidly and soon established itself as a distinct specialty. New conditions inspired men to enter the field of orthodontia. Its potential possibilities were becoming recognized. The biologic problems were being seriously considered. Occlusion and the Angle classification upon which it is based were receiving careful study, and their value in treatment was fast becoming realized. The further development of standardized appliances was given much attention. Orthodontia took a more prominent place in the curricula of many schools of dentistry and its teaching showed marked improvement. Old policies of secretiveness became obsolete. Men from the Angle school, recruited here and there by others of the same belief, went out over the country and spread the gospel of the new truths and their application to orthodontic treatment. In fact, at the end of the first decade of the twentieth century, orthodontia was riding the crest of a tidal wave which was sweeping over the country, and the trend of treatment which followed in its wake was based upon accurate knowledge rather than upon superficial opinion snatched from a preconceived interpretation. And so, fact finders in orthodontia were organizing for new aggressiveness.

The trend of treatment was fairly well established and was based primarily upon securing correct occlusal relationships. The natural and mechanical forces of occlusion were better recognized, appliances were refined and their application and use more intelligently understood. Cause and effect were delineated, diagnosis assumed larger proportions and was made, in actuality, upon the basis of knowledge acquired through study, observation, and experience and included within its scope a consideration of the biologic problems concerned in treatment. The renaissance was at hand, and orthodontia was being propelled forward by the justice of its cause and the necessity for its practice. The leaders of this crusade had accomplished a most remarkable work, but like the leaders in other branches of medicine and dentistry, their ideals were destined to receive a severe shock.

Through the concerted and enthusiastic efforts of the orthodontists, by personal contact with the dentists, by appearing before dental organizations, and by the publication of numerous articles in the journals, the value and importance of orthodontic treatment soon became recognized by the members of the dental profession, many of whom were quick to realize the opportunity

offered in this field. The laity also became rapidly enlightened and were demanding service for their children. The supply houses and laboratories started an extensive advertising campaign. Standard sets of appliances to meet the requirements of every case were offered to the profession. Laboratories advertised that appliances suitable for use in the treatment of any case would be designed and constructed, either of the fixed or removable type, upon models sent to them by the dentists, at a comparatively small cost. The financial reward appeared attractive, the field fertile, and according to the advertisements the operations were easy. Commercialism had crept in and the scenes began to shift rapidly. A large number of men were attracted by these propositions either to enter the field of practice exclusively, or to devote a small part of their time to this branch of the work. Some were qualified, some moderately so, and some were not qualified at all. Competition came into the picture, and there began a practice among a considerable number which largely ignored the results obtained in treatment. Frequently teeth were injudiciously extracted to simplify the work. The unscrupulous offered large commissions for the reference of patients. Diagnosis was given but little consideration. Appliances were selected with poor judgment, crudely constructed, and unskillfully placed. All available cases were put under immediate treatment. Fundamental principles were disregarded and the science of orthodontia was being prostituted. The trend of treatment was running its course with an incompatible mixture of good and bad, endlessly provoked by indirection and indiscretion.

The case does not rest here. The condition which existed during this decade, 1910 to 1920, still more or less prevails. Please do not misunderstand me. I refer more particularly to two classes, those who were incompetent to practice orthodontia, both specialists and nonspecialists, and those whose practices were sharp and avaricious. I also refer to the effect these things had upon the trend of treatment and not to the status of scientific orthodontia, that would be an egregious blunder without justification.

Notwithstanding this discouraging situation, progress in the science of orthodontia continued unabated, and there was probably more advancement made in this decade than in any other like period. The same thing holds true through the next decade.

Men true to the cause have never wavered and through their combined efforts and the stoutness of their hearts have piloted the good old ship safely through the raging storms on a tempestuous sea, and it is sincerely hoped they will continue to do so ad infinitum. These facts will be perfectly obvious to anyone who will take the time and trouble to review the literature of these two decades.

Now what of the trend of treatment at the present time? Is it still a mixture of good and bad? If so, which predominates?

The problems with which treatment is concerned are becoming more numerous and more complex, judgment and experience more necessary, the skill and care in constructing and adjusting appliances more exact, and the responsibilities of the orthodontist much greater. At the same time, men are entering the field more rapidly. Commercialism has taken on a more robust

form, competition is stronger, commissions by the unscrupulous and incompetent are still being offered for the reference of patients. Laboratories are better entrenched and are more brazen in their advertisements. The following are two of the advertisements appearing in a recent issue of a journal.

First.—"Personality is a most important asset in attaining success in the professional, business and social life of today. Malocclusion in its many forms is a great handicap in the development of a pleasing personality. Orthodontia should be suggested to correct malocclusion, especially for your younger patients as it will reflect to their advantage in later years. Our orthodontia department is modernly equipped, and our technicians are skilled craftsmen specially trained in appliance construction. Appliances to be constructed according to your designs, or send us study casts so that we may submit designs and estimates of cost for your approval."

Second.—"Each orthodontic appliance is designed specially for the individual case. The design is based upon our experience with thousands of cases. The quality of workmanship and materials used are equalled by no other laboratory-built removable appliance. Our appliances are standardized and simplified as to technic so that the average general dentists may carry out the treatment. Individual and personal consideration is given by our staff to any difficulties arising during treatment. We build appliances only for those cases which on analysis show themselves amenable to treatment using removable appliances. Our first fee covers the cost of the appliances, of all repairs occasioned by legitimate usage and all revisions rendered necessary by the changing requirements of the case."

There are many similar advertisements appearing constantly in various dental magazines. The futility of persons rendering efficient treatment by following such advertisements is perfectly obvious. Yet it is claimed that thousands of appliances are made and sold to dentists to be used in an attempt to correct malocclusions; a practice as obnoxious to the modern orthodontist as the archaic method of placing gold shell crowns upon anterior teeth is to the modern dentist; a practice so unscientific and ill advised that an irreparable damage will result if promoted and carried on with as much zeal in the future as it is at present. The bartering for spoils is a disreputable business to say the least, and unless trick arguments and slight-of-hand methods are discarded and men who are interested only in grinding out a living with false machinery are checkmated, the specialty of orthodontia will find itself confronted with a condition which may discredit its legitimate practice and be a sad commentary upon its scientific advancement and achievements.

If we take into account inexperience, incompetence, indiscretion, unscrupulousness, fee splitting, and commercialism in contradistinction to the practice of orthodontics by the conscientious and well-trained orthodontist with a background gained by experience and a careful study of fundamental principles, what analysis shall we make and how shall we determine the trend of treatment? We may rest assured that modern orthodontics will adapt itself to the different conditions as expressed in the character of its practice as it passes out over the world and down through the years. It is probably true that many of us in our anxiety to render orthodontic service have not utilized

to the best advantage the knowledge which has been placed at our disposal. It is also probably true that we are sometimes inclined to shirk our responsibilities. We must not fail to realize that we are dealing with a great living, growing, changing, and complex organism and that this special part of the body can be taken as an index through metabolism, posture, habit, and functional activities to be an integral part of the individual and cannot by any power of reasoning be segregated for our part of the work, nor can we ignore the fact that through racial tendencies and family resemblances there are inherent factors present which cannot be disposed of by the simple waving of a magic wand. We must not overlook the problems of development and growth, and the intricate physiologic mechanism concerned in this process, and the fact that the most favorable reactions occur when assistance is rendered at the proper time, and further, that there is a considerable variation in age in different individuals when the orthodontist will get the greatest response in his effort to assist nature in overcoming some obstructing factor. According to our best knowledge every case cannot be treated successfully or to the best advantage at the same age. Frequently orthodontic interference at the wrong time not only will cause the patient unnecessary annoyance and inconvenience but may produce a most undesirable result. It is inexcusable for anyone at present through prolonged treatment and careless methods to be causing other troubles, sometimes serious, in seeking the relief of the original one. The placing of mechanical devices upon the teeth of every child, irrespective of age or condition, who is brought to the office of an orthodontist for advice and counsel is a despicable practice and should meet with the strongest condemnation. We must remember that the most priceless gem any doctor possesses is his opinion and the confidence of his patient, and before he should dare lay the weight of a hand in the exercise of his responsibilities to fellow-men, he should regard their interests as paramount above all things else. As orthodontists we should have but a single object and that is to regard ourselves as Nature's servants, laboring as her assistants, endeavoring at all times to the fullest extent of our conception to aid in the performance of her work as prescribed by those supreme laws by which all living things exist.

The orthodontist who recognizes these things as fundamental, who considers the biologic problems along with the mechanical, who refuses to place appliances upon every case at any age, who has the courage of his convictions in giving advice and in keeping under observation those cases where any doubt exists in regard to immediate treatment, will in the end be far more successful, will find greater happiness and consolation in his work, will receive more gratitude from his patients and will avoid the necessity for so many alibis and explanations as to why the treatment has failed. We may be quite certain that compromise will always take its legitimate toll.

While it has not been my intention or purpose to depreciate the scientific advancement of orthodontia in any way, you may have been influenced to think from the analysis of conditions and the evaluation of methods that my viewpoint in regard to the trend of orthodontic treatment is somewhat pessimistic or warped. However, we may all take infinite solace in the fact that

when intelligent, courageous, and reasoning groups are determined upon the solution of a problem, there is always a way out. The labyrinth was not designed to confine men in a hopeless prison but to keep them searching for an exit. There is an exit in this dilemma, and sincerity and conscientious endeavor are certain to find it.

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DISCUSSION

Dr. Herbert A. Pullen.—In opening the discussion of this very able paper of Dr. Casto's on the trend of orthodontic treatment, which is a true record and résumé of the thought and practice in orthodontia during several decades up to the present time and including present tendencies both good and bad, I wish to say that to the *casual* reader his purpose and intent might be grossly misunderstood, and I would recommend the careful rereading of the paper and its thoughtful consideration before one is tempted to comment.

Looked at in a broad way the paper may be said to be a mirror of past and present-day thought and practice in orthodontia in which each one of us may find his own reflection, good, bad, or indifferent.

The essayist has asked a number of questions which it seems impossible to answer except by deductive reasoning and by looking far ahead of our last decade in thought and practice.

The line of thought which the essayist has followed has led him to a rather unfavorable outlook for the present trend in the specialty of orthodontia. If I read his thought correctly, we have come to an impasse from which at present there seems no well-defined exit.

Unscrupulous practices by some specialists, the appearance of the orthodontic laboratory technician, and the taking on of orthodontia by the dentist as a lucrative side line without knowledge of diagnosis and treatment seem to be the culdesac into which orthodontia has drifted through no fault of its leaders or those who have its best interest at heart.

It seems that if any dentist can hang out on orthodontic shingle advertising to the public that he is a competent orthodontic specialist, our educational institutions are seriously at fault.

In medicine if a man wishes to practice a specialty, such as rhinology, he has to major in this special line after completing his main medical course, until he can pass examinations proving his fitness to be a nose and throat specialist.

Would it not seem reasonable that the prospective orthodontic specialist should major in orthodontia in a postgraduate school of at least a year's course wherein he can receive enough didactic and clinical teaching to make him competent to practice? A few such schools are in existence, and we should look to them and others to follow for our answer to our problem.

It is true that many of our members had only six or eight weeks' special training in orthodontia, but they have had to work at a tremendous disadvantage to make up for this handicap, often for ten, fifteen, or twenty years.

This better educational path is one way out of the dilemma in which we now find ourselves if such postgraduate schools can be endowed so that they are not short-lived, but through their endowment give promise for all time of a place to send our young men seeking to practice orthodontia as a specialty.

Again, I belive that the establishment of such an institution as the American Board of Orthodontia for assuring the fitness of men to practice orthodontia is a final step in raising our present standards.

A third way out of this dilemma might be along the natural evolutionary tendencies in such a progressive specialty of dentistry and medicine.

Dr. Casto states that: "We may rest assured that modern orthodontics will adapt itself to the different conditions as expressed in the character of its practice as it passes out over the world and down through the years."

Orthodontia is still in process of evolution, and while we may find its present status one of many imperfections, its future, although seemingly obscured by the clouds of present-day tendencies, is assured by its past record, which has been one of continual progress.

Lindbergh flew blindly from New York to Paris through fog and clouds and landed in Paris in total darkness, basing his assurance of reaching his ultimate goal on the instruments and charts which had previously been used in shorter flights.

It seems to me that the answer to many of the questions propounded by the essayist as to the trend of orthodontia lies in the breadth of our vision into the future of orthodontics.

Dr. Caille Matthews told a story at Dr. Oliver's dinner which is apropos in this connection, about the darky who was called into court as a witness in a railroad accident case in which the counsel for the defense attempted to discredit the testimony of the colored witness by casting some doubt as to the distance from which he could have seen the accident, and asked the darky how far he could see. The darky replied: "How far am de moon?"

Let us for a moment ignore the obstacles to progress which the essayist has suggested and see if we cannot find underneath the surface of things a slow but sure progressive trend toward an ultimate goal of achievement, in the attainment of which these apparently insurmountable obstacles to progress may be overcome and toward which we may assume a more optimistic attitude.

During the late war there came periods of hesitancy in the fighting when one nation or another was asked to state its objective with the hope that a common ground of agreement might be found so that peace might ensue and the progress of the world continue.

In a like manner we meet together in orthodontia and state our objectives, and compare notes on whether we have reached them and are ready to go back to our practices with a new objective, a new line of thought which will give us the inspiration we need to surmount such obstacles to progress as the essayist has mentioned.

Not so very long ago it became necessary to state a new objective in orthodontia by the emphasis of the twofold aspect of its problem, the biologic and the mechanical, which Dr. Hellman aptly termed "biomechanics."

Fusing, as this expression does, the mechanics applied in the delivery of a force to the teeth and the biologic manifestation in the stimulation to growth and restoration to a functional relation as a result, it clearly stated a new objective with the stress upon the biologic rather than the mechanical.

During this last decade an attempt has been made to harmonize the mechanical treatment with, and make it subservient to the biologic principles of growth involved.

After all is said and done, the appliance is only a means to an end, a mechanical crutch, to be worn until the teeth in the dental arches are so related that perfect function

is possible when the patient, through a directed and conscious control of the weak or inefficient muscles of mastication, completes the work begun by the appliance.

The time may be nearer at hand than we think when a certain percentage of mechanical appliances may be thrown into the discard and orthodontic therapy instituted which will more nearly harmonize with that of general medicine akin to that of the practitioner of orthopedia and the posture specialist with which medical specialty orthodontia is closely allied.

It is my belief that the minority of earnest students of orthodontia, the experienced practitioners who keep abreast of the best in theory and practice are more and more inclined to the biologic trend and less to the mechanical.

If this is so, it is surely a hopeful sign, a rift in the clouds of discouraging factors which may lead to their dispersing and the clear unobstructed light of a newer, saner orthodontia more closely linked than ever with its foster parent of medicine although preserving its dental heritage.

Orthodontia is as truly a medical specialty as rhinology or otology, and I believe still is the connecting link between dentistry and medicine, although the prestige has been a little dimmed by the general health program of dentistry proper.

This may be another answer to the challenge contained in the paper of the essayist as to whether there is a way out of our present dilemma.

The story is told of an Irish hostler who, having had a few drinks, was putting his horse's head toward the carriage instead of backing him in between the thills. His companions began to jeer him about it, when he turned on them and said: "How do you know which way I am going?"

And as we might ask of the unscrupulous orthodontist, the general practitioner, and the orthodontic laboratory technician, "Do you know which way Orthodontia is going?" Take heed of the markers along the road of orthodontic progress which have biologic rather than mechanical names lest you become lost in a mechanical mire.

In the gradual evolution of orthodontia and its ensuing biologic trend, I believe we will find the general practitioner giving up his orthodontic aspirations, and the orthodontic laboratories folding up their tents, and, like the Arab, stealing away in the night.

Surely the future of orthodontia cannot show retrogression but only progress in the long run, and it is up to each one of us to lend a hand at the wheel.

Better orthodontia is being done every day, and I think we can look into the future with confidence and see a solution of our present problems in a raising of educational and professional standards and the following of high ethical standards of practice.

How far can we see? Let the darky answer: *"How far am de moon?"*

MECHANICAL ARREST OF HEMORRHAGE IN A CASE OF HEMOPHILIA*

By Wilson R. Flint, M.S., D.D.S., Pittsburgh, Pa.

THIS clinic is presented to show the possibilities of adapting principles of orthodontic appliances to assist in arresting hemorrhage in the soft tissues of the mouth. The history of the case is as follows:

At two and a half years of age the patient presented with a hemorrhage from a small spot just lingual to the maxillary central incisors. The physician reported the child as a hemophiliac or bleeder. After several unsuccessful attempts to control the hemorrhage by cauterization, an appliance was made

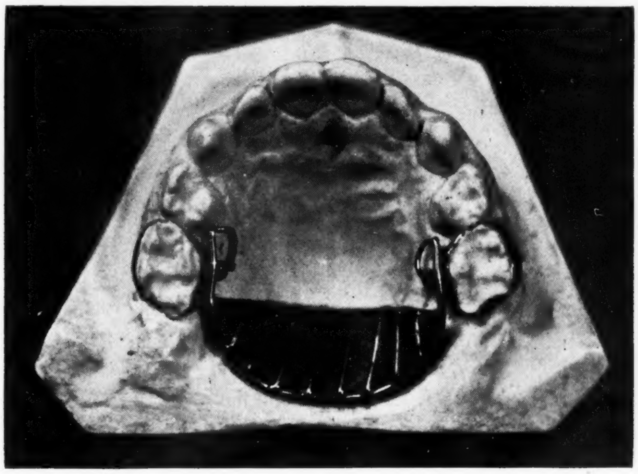


Fig. 1.

to protect the cauterized wound. The appliance consisted of a central band with an extension to the lingual to hold a small pack of cotton saturated with beeswax. With this as a protection the wound healed in three days.

At three and a half years of age the patient again presented bleeding in the median line of the vault approximately at the juncture of the soft and hard palate. The appliance as shown in Fig. 1 was constructed to hold a pack of cotton saturated with beeswax against the wound. This served as a protection to the cauterized wound until the hemorrhage was healed.

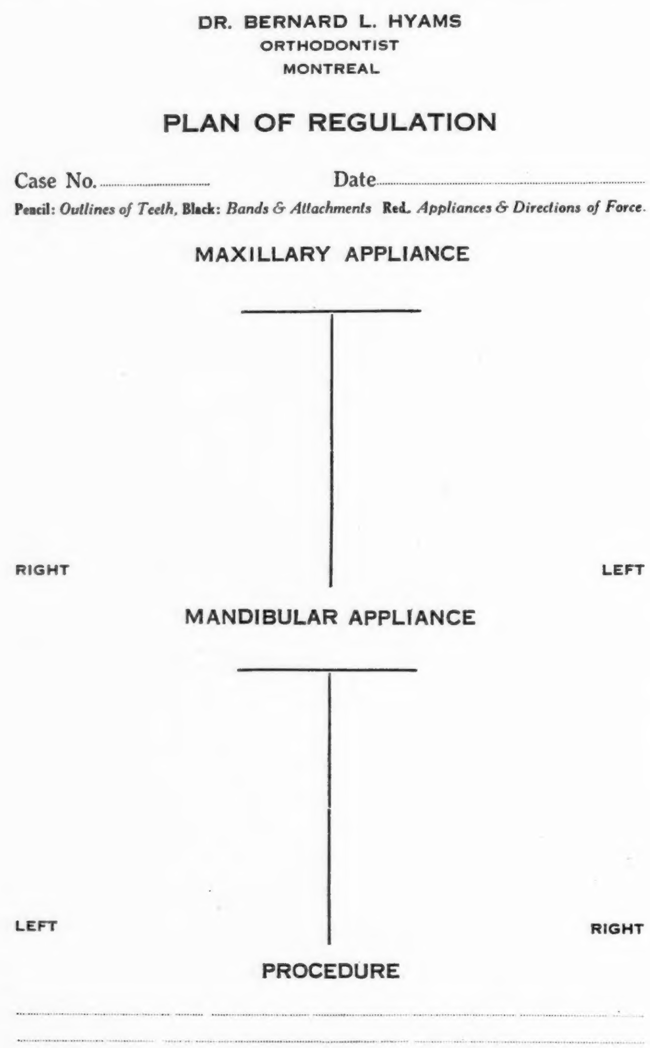
The appliance consisted of two molar bands adapted to the maxillary second deciduous molars and a crib attached to the molar bands with the ordinary half-round post and tube attachment. The crib covered considerable space about the point of the hemorrhage and held the beeswax and cotton pack against the soft tissues at that point. The appliance was allowed to remain in place for a week, after which time the hemorrhage had entirely ceased.

*Clinic presented at the Twenty-ninth Annual Meeting of the American Society of Orthodontists, Nashville, Tenn., April 8-11, 1930.

A METHOD FOR THE PLANNING OF ORTHODONTIC APPLIANCES*

By Bernard L. Hyams, D.D.S., Montreal, Canada

FOLLOWING the study of a malocclusion by the method described in a previous communication entitled, "Physiologic Diagnosis: A Key to the Regulation of Complex Malocclusions," published in the January, 1930, issue of


DR. BERNARD L. HYAMS
ORTHODONTIST
MONTREAL

PLAN OF REGULATION

Case No. .... Date ....

Pencil: *Outlines of Teeth,* Black: *Bands & Attachments* Red. *Appliances & Directions of Force.*

MAXILLARY APPLIANCE

RIGHT LEFT

MANDIBULAR APPLIANCE

LEFT RIGHT

PROCEDURE

....

....

Fig. 1.

the International Journal of Orthodontia, Oral Surgery and Radiography, it is generally desirable to work out a graphic plan for any regulation that is indicated. The method herein outlined possesses features that make its use advantageous.

*Clinic presented at the Twenty-ninth Annual Meeting of the American Society of Orthodontists at Nashville, Tenn., April 8-11, 1930.

The orientation lines for the maxillary and mandibular arches shown in Fig. 1 enable the relations between the teeth in the dental arches to be recorded in two planes, namely, the lateral plane, including the relations to the median line, and the anteroposterior or sagittal plane. These lines make it easy to obtain a very useful sketch that accurately designates the important details of a malocclusion.

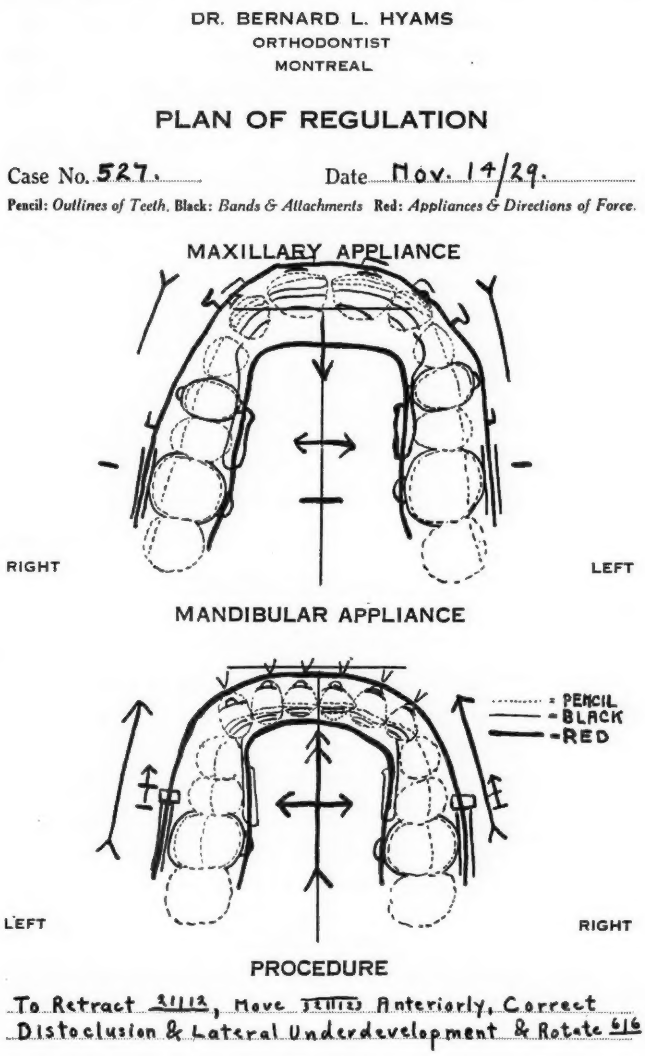


Fig. 2.

The occlusal view of the teeth is first sketched in pencil. Any required bands are then outlined in ordinary ink, and at the same time all the attachments for these bands are also indicated. The appliances are then drawn in red, including the method of attachment to the bands or teeth, such as ligatures, pins or locks.

The active forces in the appliances are now studied, and all reciprocal action is noted, so that proper anchorage may be figured out and undesired forces compensated. This check of the active forces in an appliance and of the anchorage will often prevent considerable undesired tooth movement during the process of treatment.

This working plan is a great convenience during the construction of the appliances, both at the chair and in the laboratory.

Under the heading of procedure, the purposes of the appliances are recorded at the time of their construction. This permanent record is frequently useful at a later stage of the treatment.

When the regulation of a malocclusion is undertaken in several separate stages, a series of progressive plans may be sketched, and effective appliances designed at the outset for future use.

Similarly, when a change is contemplated in the plan of regulation, this method is useful both for recording ideas and for the development of the new plan.

Fig. 2 is a working plan developed for the regulation of a distoclusion presenting lateral underdevelopment and interposition of the lip between the arches, with resultant anterior relation of the maxillary anteriors and lingual tipping of the mandibular anteriors.

DEPARTMENT OF
ORAL SURGERY, ORAL PATHOLOGY AND SURGICAL ORTHODONTIA

STERILIZATION FOR SURGERY OF THE MOUTH

By Sterling V. Mead, B.S., D.D.S., M.S., Washington, D. C.

Director, Research Department Dental School, Georgetown University

At birth the mouth and the alimentary tract are sterile. A few hours later streptococci make their appearance, and from that moment the mouth is invaded by various microorganisms. Everything that goes into the mouth—hands, toys, food, even the air—carries its burden of bacterial life. Fortunately, because of nature's defense mechanisms, and because the majority of the organisms are harmless, man may exist in happy cooperation with the bacteria he harbors, with no ill effects. It is only when his resistance is lowered, when a cut or a scratch opens up a channel of entrance, or when he encounters a pathogenic organism too strong for his natural defenses to combat successfully, that he suffers harm or is even aware of the existence of the millions of bacteria continually present.

If the dentist had to consider only the normal individual and the average assortment of bacteria, he might possibly use the same instruments on every patient who came into his office, without any attempt at sterilization or even at ordinary cleanliness. The dentist, however, particularly the oral surgeon, is not dealing with normal individuals. Many people will refuse to go to a dentist for treatment until the condition of their teeth has affected their general health, and in such a case the dentist is dealing with a patient whose resistance is definitely lowered.

With the exception of a very few diseases, the mouth is the portal of entrance for almost every infectious condition pathogenic for man. In some of these diseases there is no typical microscopic appearance, and the dentist has no possible way of knowing of the existence of the specific bacteria. Also, one patient may be carrying a strain of some organism to which he has built up an immunity, but the next patient, without such an immunity, will be in danger of becoming infected if the dentist does not exercise the ordinary precautions of sterilization.

PREPARATION FOR THE OPERATION

While there are many complications following operations in the mouth which are beyond the surgeon's control and incident to the nature of the pathologic condition, there are many infectious conditions which follow surgery of the mouth which could be prevented by more exacting rules regarding sterilization of instruments, operator's hands and field of operation, etc. Surgical cleanliness is, of course, expected of every operator, but for operations of a surgical nature in the mouth the procedure should be carried out in as aseptic a manner as possible.

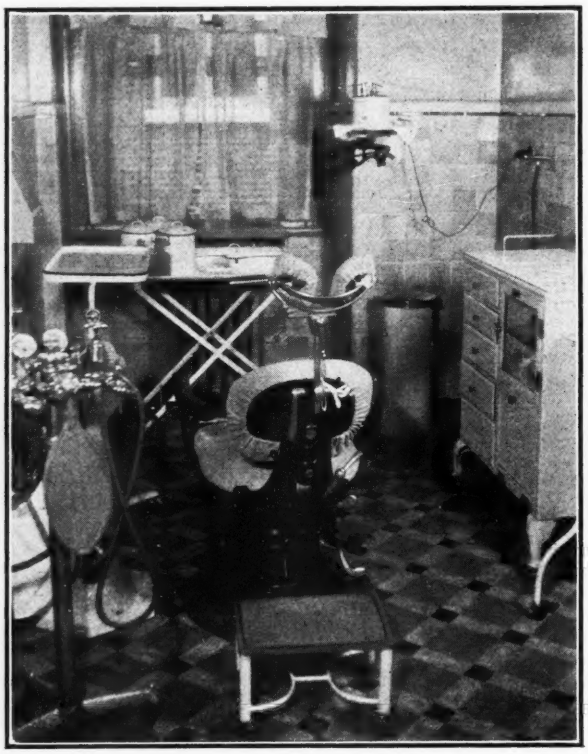


Fig. 1.—Dental operating room.

While absolute asepsis is in many cases absolutely indicated and while it is desired in every case and is to be our ideal, still we must reconcile our ideas to a procedure that is expedient and practical in every case and not require of every operator that which we would hold up as our ideal. It is not always economically possible to carry out the rigid and uncompromising factors for the maintenance of asepsis which are inseparable parts of the well-conducted hospital operating room.

THE OPERATING ROOM AND EQUIPMENT

In equipping the office of the exodontist or oral surgeon it is of great advantage to have, in addition to the usual dental operating room, a surgical operating room with a table. In this surgical operating room, in addition to the equipment supplied by the other rooms, there should be one or two drums containing sterile towels, gowns, and sheets, etc., for the cases requiring absolute

sterility. It is well to have all wash basins supplied with foot pedestals with hot and cold water so that the operator does not have to touch faucets in order to turn on the water. A soap dispenser of some kind should be available. I have found the most practical dispenser to be a wall dispenser with powdered castile soap. While liquid green soap is very satisfactory, its use in containers is somewhat inconvenient. All rooms should be supplied with a basin or receptacle for solution to be used for sterilization of the operator's hands. Elaborate furnishings in the operating room are unnecessary, and the less equipment in the room the easier it is to carry out a surgically clean technic.

A bracket table in the nature of the Mayo table is very efficient for holding instruments to be used during an operation. A cabinet should not be used for storing instruments after sterilization. If a cabinet is used at all in an

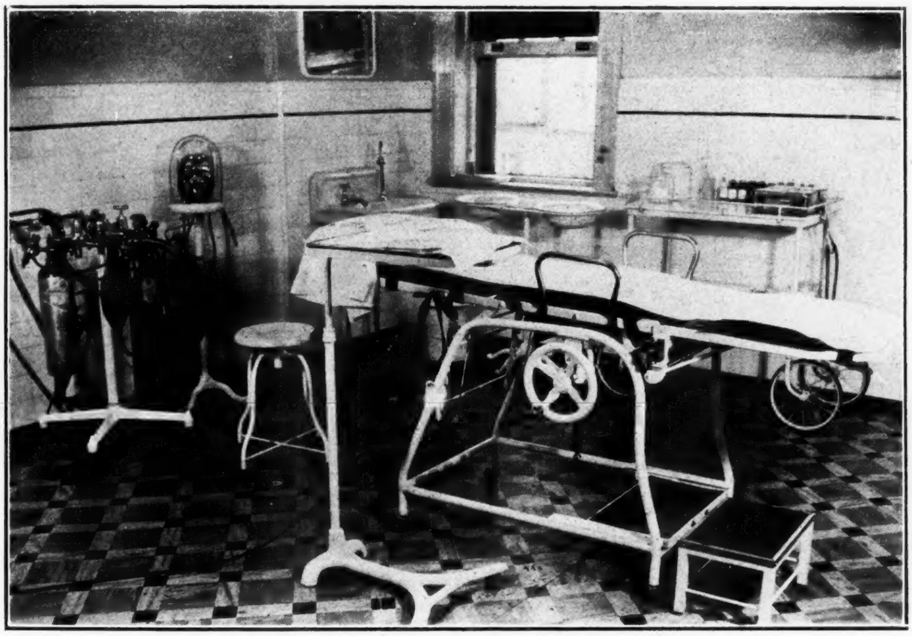


Fig. 2.—Surgical operating room.

operating room, it should be used to keep instruments and equipment before sterilization. To be ideal the operating room walls should be tile and the floor should be covered with some type of linoleum. Tile floors are very tiring for the operator and are not to be recommended. Good light is very necessary. I have found that in addition to the overhead light it is of great advantage in many cases to have a headlight.

Where there is no special system of sterilization and boiling is used, it may be permissible to have a small sterilizer in the operating room, but I do not find this the best plan. I recommend a central sterilizing plant and bringing the instruments to the room after sterilization. An engine should be available for those who have use for them. It is well to have a waste receptacle which will not show waste material, and one large enough to be of use should be chosen. There is a great advantage in having a shadow box upon the wall for illumination of roentgenograms so that the roentgenographic views may

be placed in the box and viewed during the operation when it is desired without having to handle them. There should be a push button in a convenient position in the room so that the operator may call additional assistants when it is necessary or in the case of an emergency.

The top of the table, x-ray apparatus, etc., may be sterilized by washing and wiping it with alcohol or 1 to 2,500 metaphen solution after each treatment or operation.

The rubber tubing and the bag of the gas apparatus may be sterilized by dipping into the 1 to 2,500 metaphen solution and hanging up over the sink in the sterilization room to dry.

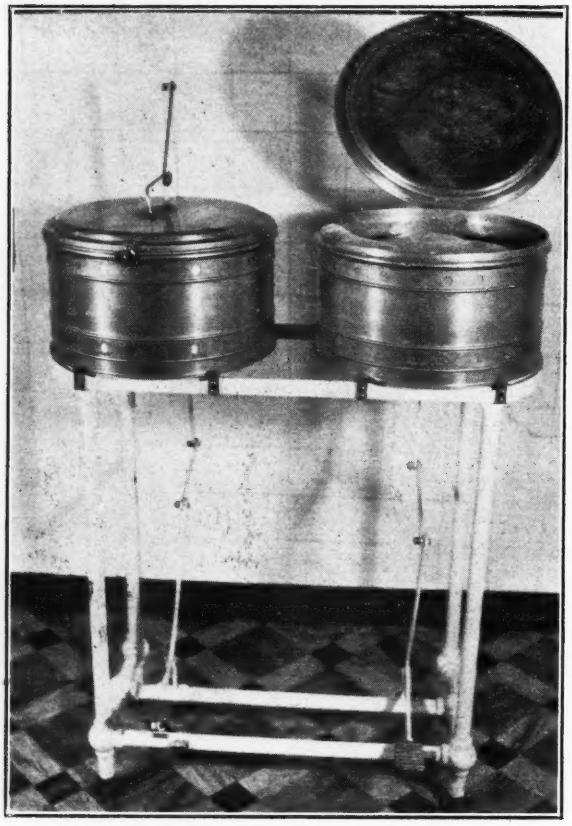


Fig. 3.—Drums for sterile towels, gowns, etc.

FIELD OF OPERATION

The mouth is a fertile field for infection, and it is constantly inhabited by various types of bacteria and microorganisms, many of which are pathogenic. The mouth usually has a high immunity against the types of infection already found in the oral cavity, and this may be accounted for by reason of acclimation to this particular environment. But it is possible that the pathogenicity of the particular bacteria may be minimized by the presence of antagonistic saprophytes.

It would seem that the great danger, as far as infection is concerned, is the danger of introducing organisms foreign to the particular field and against

which the patient does not have immunity or of opening new wounds or new fields of invasions to an overabundance of bacteria already in the mouth. While it is true that it is not possible to sterilize the mouth for any given length of time, it is always possible to reduce the number of bacteria in the mouth, and this should be our goal. We should pay particular attention to mechanical cleansing of the mouth and to the sources of infection. We should depend upon this mechanical cleansing as well as upon the chemical germicide used. The mouth should be thoroughly washed with an antiseptic solution such as liquor antisepticus, potassium permanganate, physiologic salt solution, etc. In

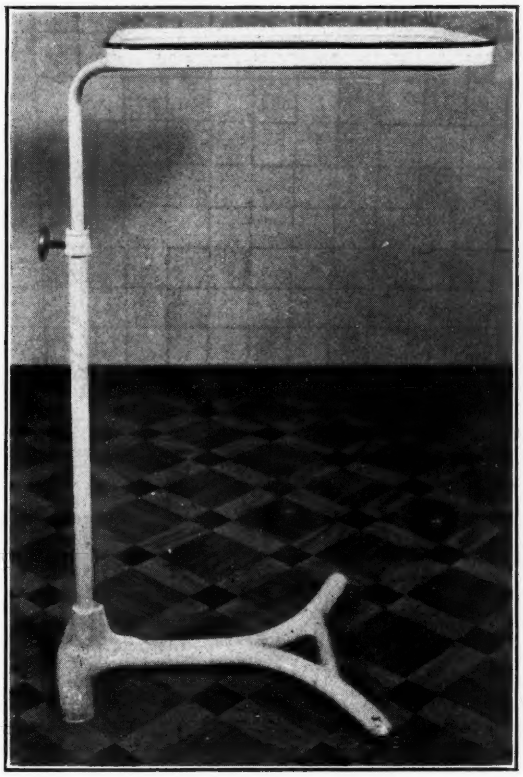


Fig. 4.—Table for instruments.

many cases it will be found necessary to remove extensive deposits of calculus, and in many cases it is necessary to give subgingival treatment where the trenches are particularly deep and where there is evidence of inflammatory reactions to the bacterial invasions. The mouth should be sprayed with a cleansing solution, and where medication is indicated it should be supplied.

In the matter of medication it is important to consider that there is a possibility, as claimed by Keilty, that the same organisms in different mouths cannot be attacked with the same chemical agent with the same degree of success. In other words, where a certain drug may have a certain specificity for the organisms in a particular mouth, in another mouth it may not have the same effect. Also the mixed nature of the organisms varies in different mouths, which will require different chemicals. It is true that this can be clinically

demonstrated, as in many cases with a particular infection the use of one drug may produce beneficial results, and with the same infection in another mouth the same drug would have very little effect. Up to the present time it has not been proved conclusively that there is any one drug that will cause the sterilization of the tissues and the death of the microorganisms in all cases. Some of the drugs tested have a high percentage of efficiency. In the routine case, therefore, it is well to use the drug which has this high efficiency rate, and in case there is resistance to this form of treatment the mouth flora should be studied and an attempt made to choose the drug which has or may have a certain specificity toward this particular organism. The drugs which have been most successful for the general use of this kind are metaphen, hexyl-resorcinol solu-

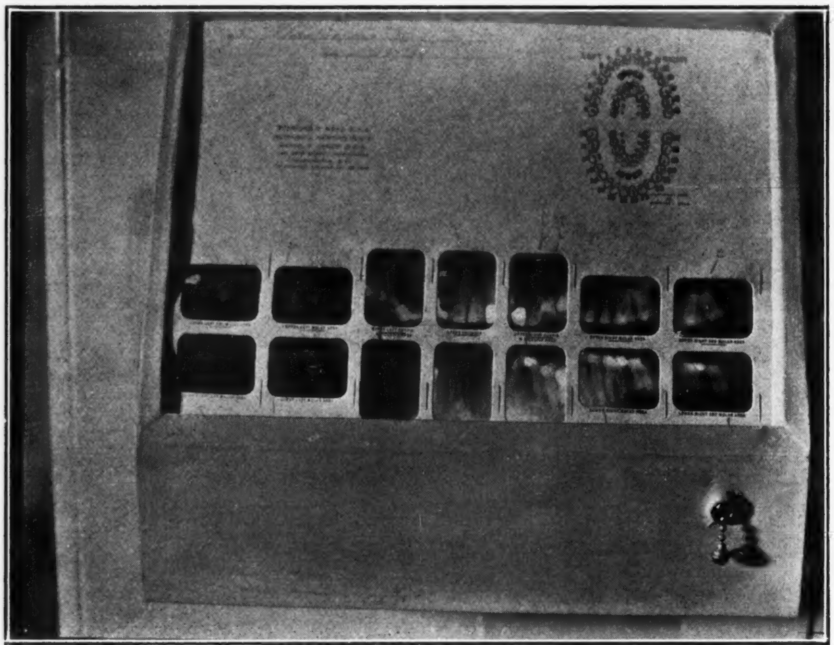


Fig. 5.—Wall illuminating box for roentgenograms.

tion (S. T. 37) 3½ per cent iodine, 5 and 10 per cent mercurochrome and mercurophen.

The particular field of operation should be dried and wiped off with a piece of sterile gauze and medicated. It is well to keep wounds free from saliva by the use of an aspirator, or by the use of gauze packs or both.

Where major surgical operations are to be performed in the mouth, such as cleft palate, etc., the mouth should be thoroughly cleaned and all pathologic areas removed, such as infected teeth, suppurating pockets, etc.

To put the patient's mouth in as clean a condition as possible, each patient should brush his teeth, preferably immediately prior to coming to the chair. This should be followed by a thorough rinsing of the mouth with some good mouth wash. This procedure is in the nature of a mechanical cleansing.

More research work seems to have been done with the skin disinfectants than with the solutions having more general antiseptic use. It is interesting

to note the results of the various experiments along this line, however, as the two fields overlap, and some solutions are adaptable for use both as a skin disinfectant and as a sterilizing liquid for instruments. In 1926 Tinker and Sutton* found that of five commonly used skin antiseptics, all failed to kill, within a reasonable length of time, most of the resistant bacteria used in the test and some of the less resistant pathogenic bacteria, under conditions of perfect contact. They used iodine, trinitrophenol, Harrington's mercuric chloride solution, mercurochrome 220 soluble, and potassium iodide.

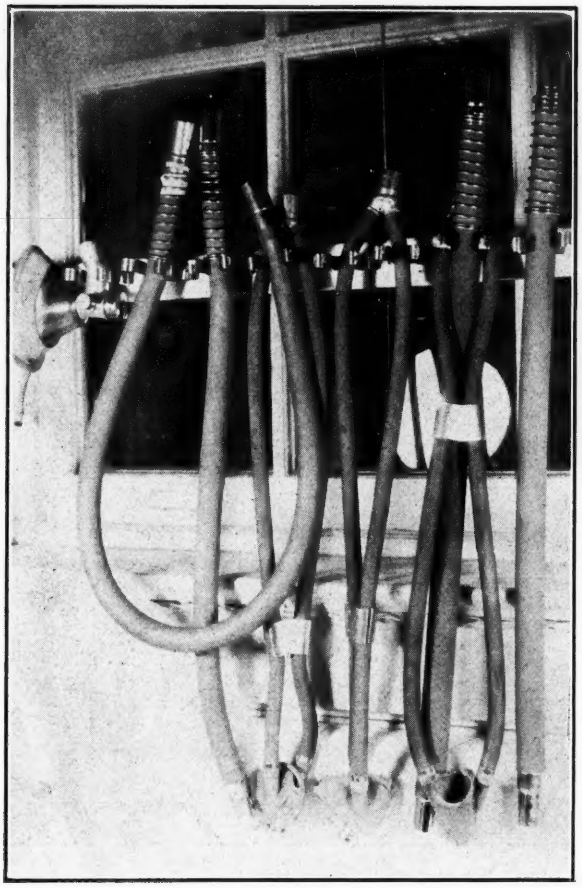


Fig. 6.—Anesthetic inhalers on rack for drying after dipping in sterilizing fluid.

In 1930 Raiziss, Severac and Moetsch, working with tincture of iodine, mercurochrome, ethyl alcohol, hexylresorcinol solution, acriflavine base and metaphen, all in various concentrations, found that metaphen was the only one which was satisfactory as a germicide and skin disinfectant.

The bacteriologist is familiar with the variations in results which he will encounter in attempting to repeat either his own or some other scientist's work. It is not necessary, therefore, to call to the attention of anyone familiar with laboratory work the oversights and uncontrolled elements in such a piece of research as that done on metaphen as a germicide, reported by Raiziss,

*Inefficiency of most of the commonly used skin antiseptics, J. A. M. A., 87: 1347, 1926.

Severac and Moetsch in the J. A. M. A. of April 19, 1930. Dr. Leonard of Johns Hopkins University, in a pertinent letter to the editor of the J. A. M. A.,* has already explained how inadequately the experiment was controlled.

It was not so much the idea of discrediting the work of Raiziss, et al., as it was to point out to the doctor unfamiliar with laboratory technic how careful he must be in accepting such reports that we decided to duplicate the experiments done with metaphen and see how nearly we could approximate the

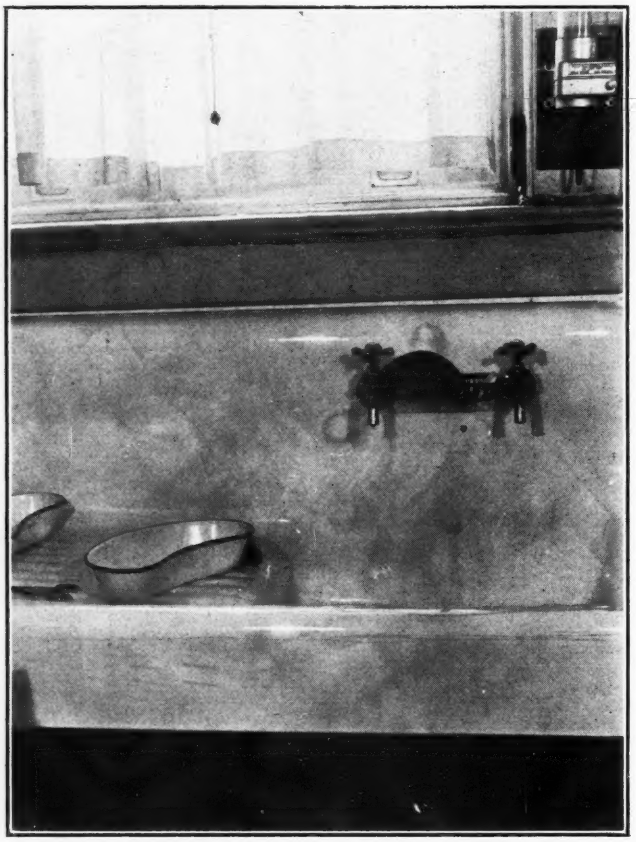


Fig. 7.—Showing sink in sterilization room for washing instruments.

reported results. In their experiment, a mixture of twenty-four-hour hormone bouillon cultures of *Staphylococcus aureus, Streptococcus hemolyticus,* and *Bacillus subtilis,* was applied to six previously sterilized skin areas of a rabbit. The material was allowed to dry. The areas were then covered for five minutes with sterile gauze saturated with the antiseptic. After the compress was removed, the abdomen was left unprotected, and cultures were made from each of the squares at intervals of from five minutes to one hour. Raiziss, et al., used various dilutions of iodine, mercurochrome, ethyl alcohol, hexylresorcinol solution, acriflavine and metaphen, and found that "the only antiseptic with which complete sterilization in all cases was obtained was metaphen." As Dr. Leonard

*May 10, 1930, p. 1524.

said, "One hundred per cent favorable experimental results involving the use of biologic material, such as living tissue of bacteria, always invite close inspection on the part of those who have been unable to duplicate such results by their own experimental methods," and after making a few trial repetitions of the Raiziss method to become accustomed to the technic, it was evident that there were so many variable elements to consider, that it was almost impossible for the same person to repeat the experiment without some variation, and that it would be quite impossible for two people working independently, to interpret the directions without marked individual variations.

We noted particularly the following points: (1) Rabbits differ in their sensitivity to barium sulphide; an irritation so produced may alter the self-disinfecting power of the skin of the involved area. (2) The amount of bouillon culture applied might vary from 0.05 c.c. to 0.3 c.c. (3) The saturation of the gauze compress is a very important point, as any excess germicide will be absorbed by the sterile swabs later, to inhibit the growth of those bacteria still alive. (4) In making the cultures there is opportunity for keeping the skin moist with broth carried on the swab from the tube to the involved area. (5) The amount of pressure exerted when rubbing the swab on the skin and (6) chance contamination from either the rabbit, air or operator during the long exposure are other uncontrollable factors. We made no attempt to control these or other variable elements or to control the more important physiologic considerations mentioned by Dr. Leonard, with this exception: of the six infected areas, only four were subjected to the germicidal compress, the other two remained unsterilized and were subsequently treated in exactly the same fashion as the first four; thus providing a method of estimating the self-disinfecting power of the rabbit's skin.

A total of three hundred cultures was made; forty with each of the following dilutions of metaphen, 1-1,000; 1-2,000; 1-2,500; eighty with another commercial germicide, and one hundred from the control areas. The results of these three hundred cultures are summarized here:

TABLE I

SKIN STERILIZATION

Rabbit No. 1.
Metaphen, 1-2,500.
Organisms: Equal amounts of twenty-four-hour growth of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF METAPHEN	METAPHEN COMPRESS APPLIED FOR FIVE MINUTES				CONTROL AREAS NO METAPHEN APPLIED	
5	+	+	+	+	+	+
15	+	+	+	+	+	+
30	+	+	+	+	+	−
45	−	+	−	+	+	−
60	+	+	+	+	+	+

Sterility control (after washing, before inoculation) −
Inoculation control (after inoculation, before application of metaphen) +

TEST.—Ten per cent sterilized by germicide (commercial); 20 per cent sterilized by natural agents.

Table II

Skin Sterilization

Rabbit No. 2.
Bard-Parker solution, undiluted.
Organisms: Equal amounts of twenty-four-hour growth of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF BARD-PARKER SOLUTION	BARD-PARKER SOLUTION COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	–	–	–	–	+	+
15	+	–	–	–	+	–
30	–	–	–	–	+	–
45	–	–	–	–	+	–
60	–	–	+	–	+	–

Sterility Control –
Inoculation Control +

Ninety per cent sterilized by germicide.
Forty per cent sterilized without germicide.

Table III

Skin Sterilization

Rabbit No. 1.
Metaphen, 1-2,000.
Organisms: Equal amounts of twenty-four-hour growth of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF METAPHEN	METAPHEN COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	–	–	–	–	+	+
15	–	–	–	–	+	–
30	+	–	–	–	–	–
45	–	–	–	–	–	–
60	+	–	–	+	+	–

Sterility Control –
Inoculation Control +

Note.—Rabbit squirmed vigorously between forty-five and sixty-minute tests.
Eighty-five per cent sterilized with germicide.
Sixty per cent sterilized without germicide.

Table IV

Skin Sterilization

Rabbit No. 1.
Metaphen, 1-1,000.
Organisms: Equal amounts of twenty-four-hour growth of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF METAPHEN	METAPHEN COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	–	–	–	–	+	–
15	–	–	–	–	–	+
30	–	–	–	–	–	+
45	+	+	+	–	+	+
60	–	–	–	+	+	+

Sterility Control –
Inoculation Control +

TABLE V

SKIN STERILIZATION

Rabbit No. 2.
Bard-Parker Solution, undiluted.
Organisms: Equal amounts of twenty-four-hour growth of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF BARD-PARKER SOLUTION	BARD-PARKER SOLUTION COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	–	–	–	–	–	–
15	–	–	–	–	–	–
30	–	+	–	–	–	–
45	–	–	–	–	–	–
60	–	–	–	–	–	–

Sterility Control –
Inoculation Control +

TABLE VI

SKIN STERILIZATION

Rabbit No. 1.
Metaphen, 1-1,000, undiluted.
Organisms: Equal amounts of twenty-four-hour broth culture of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF METAPHEN	METAPHEN COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	–	–	–	–	–	–
15	–	–	–	–	–	–
30	–	–	–	–	–	–
45	–	–	–	–	–	–
60	–	–	–	–	–	–

Sterility Control –
Inoculation Control +

TABLE VII

SKIN STERILIZATION

Rabbit No. 2.
Bard-Parker Solution.
Organisms: Equal amounts of twenty-four-hour broth culture of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF BARD-PARKER SOLUTION	BARD-PARKER SOLUTION COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	–	–	–	+	–	–
15	–	–	–	–	–	–
30	+	+	–	–	–	–
45	–	–	–	–	–	–
60	–	–	–	–	–	–

Sterility Control –
Inoculation Control +

TABLE VIII

SKIN STERILIZATION

Rabbit No. 1.
Metaphen, 1-2,000.
Organisms: Equal amounts of twenty-four-hour broth cultures of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF METAPHEN	METAPHEN COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	+	+	+	–	+	+
15	+	+	+	–	+	–
30	+	–	–	–	+	–
45	–	+	–	–	–	+
60	+	+	–	–	–	–

Sterility Control –
Inoculation Control +

TABLE IX

SKIN STERILIZATION

Rabbit No. 2.
Bard-Parker Solution.
Organisms: Equal amounts of twenty-four-hour broth culture of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF BARD-PARKER SOLUTION	BARD-PARKER COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	+	+	+	+	+	+
15	+	+	+	+	+	–
30	–	–	+	+	+	–
45	–	–	–	+	+	–
60	+	+	–	+	–	+

Sterility Control –
Inoculation Control +

TABLE X

SKIN STERILIZATION

Rabbit No. 1.
Metaphen, 1-2,500.
Organisms: Equal amounts of twenty-four-hour broth culture of S. aureus, S. viridans, and B. subtilis.

SQUARE	1	2	3	4	5	6
MINUTES AFTER APPLICATION OF METAPHEN	METAPHEN COMPRESS APPLIED FOR FIVE MINUTES				NO STERILIZING AGENT APPLIED	
5	+	–	+	+	+	–
15	–	–	–	–	–	–
30	–	–	+	+	+	+
45	+	+	–	–	–	+
60	+	+	–	+	+	–

Sterility Control –
Inoculation Control +

TABLE XI

ABSTRACT OF TABLES I-X

TABLE		PER CENT STERILE WITH COMPRESS	PER CENT STERILE—CONTROL NO GERMICIDES APPLIED
I	Metaphen, 1-2,500	10	20
II	Bard-Parker	90	40
III	Metaphen, 1-2,000	85	60
IV	Metaphen, 1-1,000	80	30
V	Bard-Parker	95	100
VI	Metaphen, 1-1,000	100	100
VII	Bard-Parker	85	100
VIII	Metaphen, 1-2,000	50	50
IX	Bard-Parker	30	40
X	Metaphen, 1-2,500	50	50

TABLE XII

SOLUTION	NO. OF TESTS	CONTROL	PERCENTAGE OF CASES OF COMPLETE STERILIZATION AT INTERVALS OF					GENERAL AVERAGE
			5 MIN.	15 MIN.	30 MIN.	45 MIN.	60 MIN.	
Metaphen aqueous solution 0.1 % 1:1,000	40	Positive	100	100	100	63	88	90
Metaphen aqueous solution 0.05% 1:2,000	40	Positive	62	62	75	87	60	67
Metaphen aqueous solution 0.04% 1:2,500	40	Positive	12	50	25	50	12	30
Bard-Parker solution Undiluted	80	Positive	68	68	68	93	75	75

TABLE XIII

THE EFFICIENCY OF GERMICIDES AFTER EIGHTEEN DAYS' EXPOSURE TO THE AIR

Materials: Ten cultures of mixed normal mouth bacteria which had been growing at incubator temperature for ten days.

To test the germicidal power of fluids exposed to the air for a period of over two weeks, on old cultures of normal mouth bacteria. (See Table I for effect on twenty-four-hour cultures.)

A. Fluid decanted from old cultures and the brain residue of one-half of the tubes immersed in Bard-Parker solution; the other one-half being immersed in metaphen. After intervals of exposure dextrose broth tubes inoculated with lumps of brain material removed with a sterile loop.

B. Swabs which had stood in the culture tubes during the entire ten days of inoculation removed and subjected to immersion in Bard-Parker and metaphen for intervals of one, three, and five minutes.

TIME INTERVALS		ONE MINUTE	THREE MINUTES	THREE MINUTES	FIVE MINUTES	FIVE MINUTES
Metaphen	A	–	–	–	–	–
	B	–	–	–	–	–
Bard-Parker	A	–	–	–	–	–
	B	–	–	–	–	–

NOTE.—Tubes incubated four days before reports made.

TABLE XIV

SOLUTION	PERCENTAGE OF INOCULATED AREAS STERILIZED	PER CENT STERILE-CONTROL (NO GERMICIDE APPLIED)
Metaphen, 1-1,000	90	65
Metaphen, 1-2,000	67	55
Metaphen, 1-2,500	30	35
Bard-Parker Germicide	75	70

Table XIV indicates the futility of such a method of investigation; since it is evident from the way the control averages conform to the test averages that the variable, uncontrolled factors have more influence on the results, probably, than has the type of germicide used.

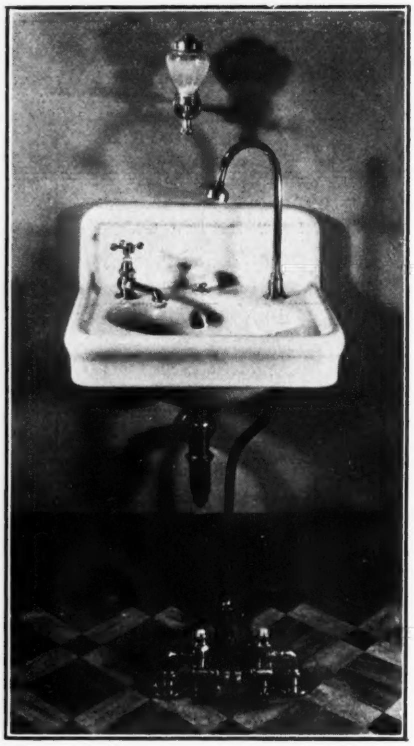


Fig. 8.—Soap dispenser and wash basin with foot control.

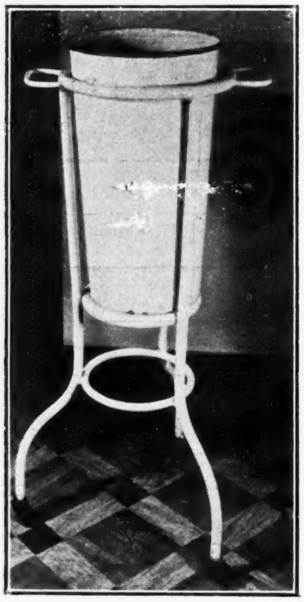


Fig. 9.—Single basin for hand and arm sterilization.

CARE OF THE OPERATOR'S HANDS

The operator should first prepare his hands and arms by scrubbing them five minutes or more if necessary with hot water, castile soap or tincture of green soap and a sterile brush. Particular attention is given to the nails, which are cleaned with an orange wood stick. The physical cleaning of the hands is of more importance and advantage than the application of drugs. It is not possible to sterilize the hands completely, as even the pores contain microorganisms. While these organisms are usually not pathogenic, the scrubbing will reduce the number, will lessen the amount of medium, such as desquamated epithelial cells, and so forth. It has been suggested that before the first operation of the morning or afternoon, the perfectly dry finger tips may be im-

mersed in U.S.P. tincture of iodine, so as to cover completely the nails and spaces around them up to the terminal phalangeal joint. This is allowed to dry thoroughly. The scrubbing process is then carried out in the usual manner, the hot water removing a great deal of the iodine. At the end of the first operation when the gloves are removed, all traces of the iodine will have disappeared. There is not the slightest skin irritation or other untoward effect.

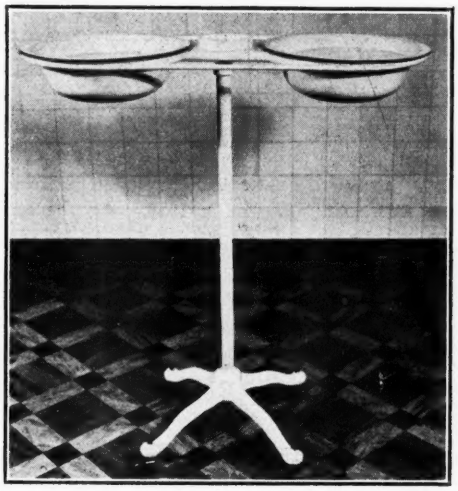


Fig. 10.—Double basin for liquids for hand sterilization.

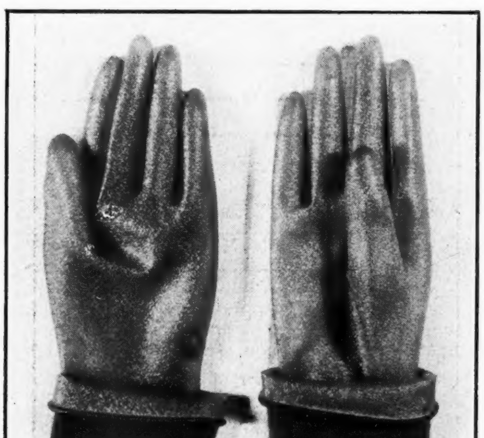


Fig. 11.—Rubber gloves with rough finish.

I believe that an operator should always wear rubber gloves for surgical work of any nature in the mouth and even in the treatment of these surgical conditions. It is much easier to sterilize the hands with gloves, and, of course, in a plan of strict asepsis it is possible to have the gloves come from the autoclave absolutely sterilized. It is not always economically and otherwise possible and practical in dental cases to have a new pair of gloves for every patient; but even though the same gloves are worn, they will usually last at least a half day and can be sterilized after removal, properly prepared, and used again

There is an added protection to the patient, and there is also a very great protection to the operator, as the hands usually have scratches or lesions of some kind where infections can occur. The operator, therefore, wearing gloves is running much less danger to himself than he would run otherwise. By using the proper size gloves and ones with a rough surface such as the No. 108

Fig. 12.—Patient prepared with sterile sheet and towels, ready for operation.

Fig. 13.—Showing sterile towel clamped on operator's gown.

Knucklefit Glove made by the Lincoln Rubber Company, the operator can so accustom himself to the use of gloves in handling instruments that they will not interfere in the least with his work, and he will not mind their use at all.

For the hospital cases and where strict asepsis is carried out, it is, of course, not necessary again to immerse the hands after putting on the gloves, but in the usual routine of the dental office it is necessary again to sterilize the hands

after putting on the gloves. The hands should, therefore, be immersed in some antiseptic solution and dried on a sterile towel. I prefer to immerse the hands, after washing them, in a solution and dry them on a sterile towel before putting on the gloves, as they are more comfortable dry than wet. The hands may be immersed in a 70 per cent alcohol solution, a 1 to 1,000 bichloride of

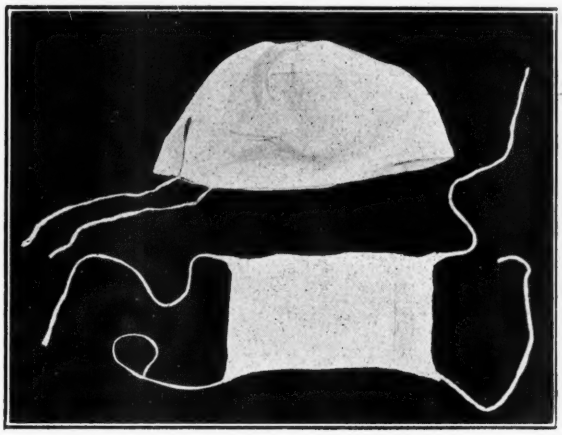


Fig. 14.—Cap and mask which may be worn instead of the Mayo mask.

Fig. 15.—Surgical gown and Mayo mask.

mercury solution, or a 1 to 2,500 metaphen solution. I prefer the 1 to 2,500 metaphen solution. After the hands have been sterilized, the operator should be careful not to touch anything foreign to the field of operation. The adjusting of the chair, the handling of the furniture, the closing of the door, and all such procedures should be accomplished by an assistant.

The above preparation may be modified or enhanced by scrubbing the hands with a small amount of chloride of lime and washing soda, dissolving in the palm of the hand, then washing off and dipping into an antiseptic solution.

After the gloves are used, they may be washed with soap and water or immersed in lysol for ten to fifteen minutes or boiled for ten minutes. They should then be dried, and powdered both inside and outside with talcum powder and put between pieces of muslin, placed in a container, and then sterilized again in the autoclave for ten minutes with not more than fifteen pounds pressure, at 250° F. When holes appear, the gloves may be patched and used again.

Fig. 16.

LINEN

In office practice the patient is usually requested to remove collar, coat, or anything that will add to his comfort or convenience. The patient should then be covered with a clean rubber apron or sheet, and a sterile towel is placed over this. I prefer the apron made from stork sheeting which may be made in convenient size, and by having a great number of them on hand they can be washed and dried after each patient. Of course, where the operation permits or where it is practical, the individual sterile sheet and linen should be supplied. For operations of this kind a supply of sterile towels should be kept, so that they can be used to protect the patient's head, over the patient's chin and chest, etc. (Fig. 12.)

The operator should be dressed in white trousers and operating coat, preferably with short sleeves. It is very convenient and economical to place a sterile towel on the front of the operator's gown by the use of Sharp and Smith clip as shown in Fig. 13.

In a strict hospital technic where asepsis is carried out fully, the operator should be dressed in white trousers, sleeveless shirt, face mask and head cap, and after scrubbing up he then puts on a sterile operating gown and gloves (Figs. 14 and 15).

SPONGES AND DRESSINGS

Sponges and dressings are made of cotton and gauze of various sizes which may be kept on hand. These may be sterilized in the autoclave and placed in gauze packs, and the unused portion may be resterilized. The sponges and dressings may be sterilized in linen, muslin, or gauze packs. Applicators, swabs, wooden tongue depressors, etc., should be subjected to the same degree of sterilization.

Another plan is to have the different articles placed upon a table in the operating room in containers which have been autoclaved with the contents. The material may be removed with a pair of tongs kept in a sterilizing solution upon the same table.

On the dressing table may be placed a jar containing metaphen 1-1,000 or some other solution, containing tongs with which to remove gauze and cotton from the containers without contaminating the other material. On this same dressing table may be kept another pan with sterile cotton pliers, and the pliers may be removed one at a time with a pair of tongs out of the other solution without contaminating the remaining pliers.

If the operator uses ampules, carpules, or novampules, they may be placed in 70 per cent alcohol or 1 to 2,500 metaphen just before using and picked out of the solution with sterile pliers and dried on sterile gauze. When the novampule is used, the file used for cutting the glass end may be kept on a hemostat in the sterilizing solution, and the nurse may saw the glass while the novampule is held by the operator or the operator may break the glass by putting the tapering end through the barrel of the syringe and breaking it.

(To be continued in November issue.)

ABSTRACT OF
CURRENT LITERATURE

NUTRITION AND PEDIATRICS

By Samuel Adams Cohen, M.D., New Yerk City

It is the purpose of this Journal to review so far as possible the most important literature as it appears in English and Foreign periodicals and to present it in abstract form. Authors are requested to send abstracts or reprints of their papers to the publishers.

Nutrition and Pediatrics

The Response of Reticulocytes in Secondary Anemias Following Various Forms of Treatment. C. S. Yang and Chester S. Keefer. Arch. Int. Med. **45**: 456, 1930.

Writing from the Department of Medicine, Peiping Union Medical College, Yang and Keefer report their observations in the reticulocyte response in 53 cases having various forms of secondary anemia.

It is generally agreed that reticulocytes are young and immature red blood cells, and their presence in the circulating blood is 1 per cent of the red blood cells or erythrocytes. With the exception of normal infants up to the age of six weeks, and with premature infants a little later than this age, any increase in the reticulocytes above 1 per cent is considered an increase above the normal, and is an indication of increased activity on the part of bone marrow.

Minot and Murphy and others have pointed out that when patients with pernicious anemia were fed large amounts of liver there was a rapid increase in the production of hemoglobin, erythrocytes, and reticulocytes, and now Yang and Keefer, in accord with others, also report that many forms of secondary anemia react in the same way following treatment with liver or liver and iron. When nutritional disturbances seem to play a part in the production of anemia, it is obvious that a high caloric diet, in addition to liver or liver and iron or cod liver oil, is productive of the most favorable results.

In their conclusion Yang and Keefer hold that feeding of liver as a method of treatment in anemia is not as specific for secondary anemia as it is for pernicious anemia, but nevertheless, liver has a beneficial effect upon many forms of secondary anemia. They further state that in many instances liver and iron together are more effective than when liver or iron is taken alone.

Seasonal Variation in Hemoglobin. Virginia E. Platt and R. J. Freeman, Jr. Proc. Soc. Exper. Biol. & Med. **27**: 7, 1930.

Platt and Freeman studied the possible variation of hemoglobin in a group of children between the ages of twenty-one and forty-four months. These children were attending a nursery school in New York City, and came from a

superior social group, and naturally, their dietary and environmental conditions were above the average. Their hemoglobin averages indicated that the February figures are all below those of November, and from available data the peak is reached probably during the summer months. The low point of February also corresponds to the time when children are supposed to have their lowest growth period. Moreover, this is the time of the year in which there is the greatest incidence of upper respiratory tract infections.

The Effects of High Sugar Diet on the Growth and Structure of the Rat. C. M. Jackson. J. Nutrition **3**: 1, 1930.

The consumption of sugar in the United States has steadily increased from 38 pounds per capita in 1875 to between 110 and 115 pounds per capita in 1924 to 1927.

The literature on the harm of excessive use of sugar is somewhat contradictory. Indirectly, however, excessive use of sugar may be detrimental, because this often results in underfeeding of proteins, fats, or salts, more especially of calcium and iron, or of vitamins.

Because of the prevailing opinion concerning various possible injurious effects of such diets, Jackson, writing from the Department of Anatomy, University of Minnesota, Minneapolis, reports his experiments with 36 rats observed from time of the weaning to nearly adult stage on balanced diet. The control rats were fed on 45 per cent starch, test rats on 45 per cent sugar diet, and some test rats on 80 per cent sugar diet (sucrose). Jackson observed that in all cases the rats thrived on the diets and were normal in every appearance and in their behavior. This expert also noted that the sugar-fed rats were normal in their estrus cycles and, therefore, presumably normal in ovulation. In regard to the observation on their teeth, the author, who is considered an authority on foods and their effects upon growth and structure, states that it is "evident that high sugar diets for long periods are not necessarily injurious to the teeth." Moreover, he found that there was no significant difference in the incidence of pulmonary infections between the starch-fed and the sugar-fed groups. Moreover, with the exception of the liver, the organs, both gross and histologic sections, showed practically no changes. Jackson did find in these sugar-fed rats, and also in an additional series of 20 adult rats (which were also given high sugar rations) that for some obscure reason these rats had a greater tendency to have a fatty deposit in their liver cells.

Vitamin G in Certain Meats and Meat By-Products. Ralph Hoagland and George G. Snider. J. Agricultural Research **41**: 3, 1930.

Vitamin G is now generally used in the United States to denote water soluble vitamin which is necessary for growth in rats, and presumably for growth in other animals. In Great Britain the term vitamin B_2 is used to denote the same vitamin.

Since Goldberger indicated that lean fresh beef was a fairly good source of growth-promoting vitamin G, these investigators tested by animal experi-

mentation a number of kinds of meats and meat by-products as sources of this vitamin. They found that beef, pork and lamb appeared to contain approximately the same quantities of vitamin G, also that beef spleen contained approximately as much vitamin G as beef. Beef liver, pork liver and beef kidney were found to be rich sources of vitamin G and contained approximately from five to eight times as much vitamin G as beef, pork or lamb.

Value of Uncooked Food. Prof. A. Loewy and W. Behrens. Klin. Wchnschr. **9**: 390, 1930.

These investigators report an interesting observation on seven adults —four males and three females—who were allowed to partake of all the uncooked foods they desired for from three to five days. Their diets during this period consisted of uncooked fruit, such as banana, apple, figs, of uncooked vegetables, such as spinach, tomato, carrots, also cereals, nuts and salads.

An examination of their stools showed that there was an energy loss of food value ranging from 22.3 per cent to 38.2 per cent.

Perhaps the most important observation is the fact that in no instance did any of the subjects have an intake sufficient to cover the daily caloric requirements.

The Relationship of Deficiencies in Vitamin A and D to Infection. William Bradford. Read before the Philadelphia Pediatric Society, March 11, 1930.

Using 23 rats as a control group, Bradford studied the effects of another group of 23 rats fed on vitamin A deficient diet artificially infected with a bacillus of the mucosus capsulatus group. These experimental animals were infected in subgroups after they were on this vitamin A deficiency diet for four, six, eight and ten weeks respectively, and Bradford noted that these subgroups showed increased susceptibility to the injection before there was clinical or anatomic evidence of deficiency in vitamin A.

Similarly another group of 23 rats and 23 controls was tested with the exception that these experimental animals were on a deficient vitamin D diet.

Bradford feels that these studies suggest that vitamin D per se is not so important as a factor of lowering resistance to infection as is generally believed. From a clinical point of view a diet so low in vitamin D as to lead to markedly active rickets is probably also relatively low in vitamin A, and this fact may explain why some rachitic children suffer from infections.

The Nutrition of Sick Children. M. G. Peterson and Irma Hug. Am. J. Dis. Child. **40**: 2, 1930.

Peterman and Hug, reporting from the Department of Pediatrics, Marquette University Medical School, studied the food requirements of thirteen children in an orthopedic ward in the Milwaukee Children's Hospital from January 19, 1929, to October 18, 1929.

These children were hospitalized because of chronic bone disease (9 patients had tuberculous bone lesions).

The authors feel that more attention should be paid to the food intake of these children, and they remark that it is surprising to note that when children who appear to be ingesting an adequate amount of food are encouraged to eat more and are given supplementary food they may actually receive from 9 to 69 per cent above the optimum basal requirements for their expected weight.

They recommend that the food requirements of children with chronic bone disease, especially tuberculous disease, should exceed 50 per cent above the basal requirements calculated on the basis of the "normal" or expected average weight or height.

Vix Medicatrix Naturae in Pediatrics. Joseph Brennemann, Am. J. Dis. Child. **40**: 1, 1930.

In his presidential address before The American Pediatric Society, Brennemann makes some pointed remarks, which reflect some of his observations during his thirty years of practice. His general theme is that in the field of pediatrics, particularly, nature is a potent factor in restoring the pathologic to the normal and that it is the part of common sense to recognize and utilize nature more freely and frankly. He is not unmindful of the fact that the necessity of doing something is so deeply rooted in human psychology that it can never be ignored.

Brennemann deplores the present trend of some physicians who consider laboratory data as the last court of appeal, often to the exclusion of their own clinical impressions. The author further states that it is becoming more and more difficult to take care of the feeding of children, because the mother's knowledge of nutrition has increased to the extent where it interferes with its practical application with her own children. He feels that the harmful results of the misapplication of mother's knowledge of nutrition has been the increasing number of children who refuse to eat. It may surprise many to learn that 50 per cent was the lowest estimate of the number of children who come to private practitioners for that particular reason. To quote further the author states: "The better mentioned the home, the better the food, the more precise the application of feeding rules and regulations, the more stubborn the refusal." Curiously enough anorexia occurs only in the home, since it is a rare situation in convalescent wards in the hospitals, camps and in the orphan asylums. He attributes this situation to the reasons: first, the natural negativism of the child and the strong will to back it; and second, the desire of the child to be distinctive, that is, to have the spotlight whether it be for good, bad, or unusual behavior.

To counteract the tendencies of children to capitalize in their failure to eat, the author states that he has made it a practice to tell every mother never to make or urge her child to eat.

Among other present-day abuses are those concerned with purgation and starvation. He feels that these proceedings are often carried to extremes for no particular purpose except perhaps a hang-over of former times when bowels were erroneously considered as almost the only locus and entry of infection. Brennemann is very much opposed to the common practice of using strong antiseptics and medication for many pathologic conditions which nature

seems to be well able to handle. In some instances he feels that these do harm, and some, moreover, have a most unpleasant physical and mental effect on the child.

Labrador—A Lesson in Practical Nutrition. Editorial J. A. M. A. **95**: 9, 1930.

According to an editorial in *The Journal of the American Medical Association,* the report of Dr. Helen S. Mitchell of Battle Creek College, who undertook a nutritional survey during the summer of 1929 among the fisher folk of Labrador and Northern Newfoundland, suggests an opportunity for the nutritionist.

In these regions, there is a widespread occurrence of night blindness, beriberi, rickets, mild scurvy and undernutrition.

A unique feature, in some of these regions, is the practice of the women folk to obtain the twelve months' food supply for their family each fall. They, therefore, have to calculate the number of gallons of molasses, barrels of flour, etc., which will be consumed by the family during the next twelve months.

In spite of this, according to Mitchell, there is adequate food fuel, but there is a noticeable deficiency in their mineral and vitamin requirements. Although their phosphorus requirements were met because of the natives' large consumption of flour and fish, their calcium intake was low for the same reason.

Obviously, the editorial comments, with such a diet, the calcium-phosphorus balance is thrown so far off as to predispose every child on such a diet to serious bone and tooth defects. In view of this, it is not surprising, therefore, that Mitchell reports that many of the children showed jaws full of hopelessly decayed and broken teeth.

Indications and Contraindications for Removal of Tonsils in Children. P. D. Davydoff. Brit. J. Child. Dis. **27**: 316, 1930.

In a paper read before the Laryngological Section of the Toganrog Medical Association, the author, who writes from Toganrog, Russia, reviews some of the recent studies reported regarding the tonsils. It is his opinion that any attempt to assign a special function to the tonsils, which is different than all the rest of lymphatic tissue, has failed. Because of their prominent situation in the digestive and respiratory tract, the tonsils have a different pathologic reaction than the other lymphatics.

Davydoff is in accord with most authors in regard to the indications for the removal of tonsils, namely, "recurrent attacks of tonsillitis, oral foetor, pain in swallowing and other phenomena associated with tonsillitis, and lastly, cervical adenitis due to organisms and toxins derived from the tonsils."

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EDITORIALS

Orthodontics and Dental Economics

DURING the last few years, dental economics has been one of the important matters of discussion by the dental profession. We find that this subject sprang into prominence a few years ago, as the result of various men and organizations advertising courses on dental economics for the dentist. Some of these courses were highly successful judging from the number of men who received instruction and the favorable opinions expressed by these men after having taken the courses. In most of these courses on dental economics, various branches of dental operations were analyzed regarding the cost to the dentist in rendering the service. It was claimed by some men who were giving courses in dental economics, that the average orthodontic operation as performed by the general dentist, is unprofitable. Consequently, we find in some

courses the recommendation has been made that the general practitioner confine himself to dental operations which will show a direct profit.

According to our observation, we also believe the average orthodontia case handled by the general practitioner, if said case is carried to satisfactory termination, is a liability. The general dentist is unable to collect a fee sufficiently large to compensate him for the time spent upon the case. However, we find a certain group of dentists who have obtained their information from dental laboratories, doing a certain amount of orthodontic work without the proper training. These men have been informed by the dental laboratories that they can have appliances made on a set of models which will cost them a certain sum. The dentist is instructed to charge a fee when the appliance is inserted and then to collect a monthly fee thereafter. In the majority of these cases, the dentist knows nothing about the malocclusions to be treated and less about the appliance he is operating. A great many of these men have come to orthodontists for advice and assistance, and after a short conversation the orthodontist has learned that the general practitioner is entirely unqualified to handle the case he has attempted to treat. In some of these instances, the orthodontist has advised the dentist to discontinue attempting to treat malocclusions until he learns more about the condition he is handling and has gained more knowledge regarding the adjustment of the appliances.

When this advice is given, a great many general practitioners inform the orthodontist that he (the dentist) will not stop treating malocclusion because he collects enough money from these patients to pay his rent. In other words, the attempt to render orthodontic service is placed purely on an economical basis so far as the dentist is concerned. The dentist is not bothered by the fact that his patient is not receiving a service in keeping with the fee paid. The attitude of these general practitioners is to collect the fee each month regardless of how satisfactory the service rendered may be.

It is our belief that such a procedure by general dentists is nothing more than taking money under false pretense, and the patient suffers in two ways: first, the orthodontic service is a financial loss to the patient; and second, in a great many instances the attempted treatment is an actual detriment. It is our belief the conscientious dentist will try to render service for the fee collected, even though he may have to do some other operation to assist in paying his rent.

It is indeed unfortunate that orthodontic laboratories, whose sole purpose is the selling of orthodontic appliances, have come into existence. A very clever orthodontic appliance salesman can easily convince a dentist, whose time is not all occupied, that he can increase his income by selling attempted orthodontic service to his patients along the lines we have mentioned. If the patient were the only person involved in this transaction, it would be bad enough; but the patient is not the only one who suffers. Owing to unsatisfactory orthodontic service which this patient receives and the harm which may be done as the result of improper treatment, the patient advises others against orthodontic treatment. Consequently, many people listening to the advice of dissatisfied patients will go through life with malocclusion and facial deformities which could be very easily corrected if handled properly. There-

fore, a great many people suffer as a result of one unsatisfactory attempt at orthodontic treatment, the purpose of which has been only a fee to be collected by the general practitioner.

We realize that this problem, as serious as it is, cannot be satisfactorily disposed of. As long as certain individuals can collect a fee for attempted service, they are going to continue to collect that fee. We regret exceedingly that there are men in the dental profession who consider orthodontia as an economical problem and not as one designed to render service to suffering humanity.

IN MEMORIAM

DR. EDWARD HARTLEY ANGLE

An Evaluation

By Richard Summa, St. Louis, Mo.

"I HAVE finished my work; it is as perfect as I can make it," were among the last words uttered by Dr. Edward H. Angle. While there is no reason to take these words as a knowledge of the then impending end, they nevertheless sound prophetic.

On August 11, 1930, Dr. Edward Hartley Angle yielded to the inevitable law of nature. His passing, as in the case of all other benefactors of mankind, removes only the physical part of his being from our midst. In the fact that the spiritual character of man's mundane existence endures beyond his last resting place lies the only solace that can be offered for the greatest of human heartaches.

Let the good that men have done live long after them. The benefaction of human achievements cannot be confined to members of any vocation but is, moreover, bestowed upon mankind at large.

The profession of dentistry must append the name of Edward Hartley Angle to the small list appearing on the first page of its roster.

Dr. Angle was inspired to recognize an obvious anatomical fact and apply its meaning to the correction of malposed teeth. Viewed in the light of present-day knowledge, it is astounding that the recognition of occlusion of the teeth as the basis of orthodontic procedure had to await so late a day in the history of dentistry. The delayed recognition and the amazingly slow acceptance of this glaring fundamental fact by the dental profession serve only to add credit to the memory of the man whose logical demonstration and perseverance have taken the practice of orthodontia out of chaos. It required a Herculean effort to efface the perilous empiricism under which orthodontia suffered.

The illogical opposition, of thirty years ago, to his teaching spurred Dr. Angle on to seek higher ideals and toward perfection. He sought to perpetuate his work by instilling his enthusiasm and ideals into men of ability. In this endeavor he succeeded to an extraordinary degree. Pity 'tis, that his early struggle in behalf of what he believed to be correct and which is now almost universally accepted as right embittered him and thus clouded his better judgment in his dealings with friend and antagonist. He tried to hasten and force a better comprehension of his tenets by assuming the rôle of censor. Independent thought, even of a constructive nature and in accord with his fundamental principles, incurred his veto. It was to be expected that men of the caliber he accepted as students would endeavor to employ their initiative to assist in solving the numerous difficulties which confront the orthodontist. To the great surprise of these collaborators all advances pertaining to the mechani-

cal and scientific problems were construed by him as heresy calling for an irrevocable ostracism of him who dared to think. This policy resulted in personal estrangements which impeded happiness and the rapid stride of this dental specialty. The beautiful vision of a deservedly great man posing on the high pedestal of fame and emanating his achievements through a worshiping band of disciples was thereby destroyed.

Dr. Edward H. Angle was born at Herrick, Pa., June 1, 1855. His youth was spent on his father's farm, and his early education was obtained in the country schools of that vicinity. From that time until he graduated from the dental college he experienced the vicissitudes which so many American lads encountered in their rise from the farm to a professional career.

In 1878 he graduated from the Pennsylvania College of Dental Surgery and entered the practice of his profession in Towanda, Pa. At this time he made his first attempt to straighten "crooked teeth." The patient, as he told the writer, was his preceptor's son. This case surprised him with many perplexing difficulties; thereby it became his incentive to solve the correction of malocclusion. It seems his journey upstream started here and continued until August 11, 1930.

Ill health induced him to spend a few years in the higher altitude of the West. Upon his return eastward, he located in Minneapolis, Minn., where he served as professor of orthodontia at the Dental College of the University of Minnesota. In 1892 he accepted the professorship of orthodontia at the Northwestern University Dental School at Chicago. In 1897 he located in St. Louis, Mo., where he became connected with the dental departments of the Marion Sims Medical College and Washington University. In the same year he received the degree of M.D. from the Marion Sims Medical College, and in 1915 the University of Pennsylvania conferred upon him the Sc.D. degree.

In 1900 he established his Postgraduate School of Orthodontia in St. Louis, Mo. This memorable event introduced orthodontia as a distinct specialty of dentistry. Under the leadership of Dr. Angle and with the assistance of a few enthusiastic and idealistic pioneer students a course including such ancillary subjects as histology and embryology of the head, human and comparative anatomy of the teeth, rhinology, and facial art with reference to orthodontia was developed. The thoroughness of this curriculum caused orthodontia to take a preeminent place among the special branches of dentistry.

During the period intervening between 1900 and 1928 he conducted postgraduate courses in orthodontia at varying periods in St. Louis, then in New London, Conn., and finally in Pasadena, Cal. By means of these courses he found and developed kindred souls. He had a right to feel proud of the alumni of his school. This union of teacher and pupils gave great promise of congeniality and scientific cooperation. Unfortunately, Dr. Angle's apparent attitude of an absolute censorship marred such prospects and led to serious misunderstandings.

No contributions to dental literature assume a higher rank than those of Dr. Angle. The wealth of knowledge to be derived from his writings on orthodontia is unexcelled. His literary style is lucid and fluent. His meaning cannot be misconstrued. While there can be a difference of opinion regarding his

recent methods of treatment, the fundamental principles of orthodontia promulgated by him are the most rational yet submitted and give promise of remaining indisputably correct.

Be that as it may, the world has been enriched by the life of Dr. Edward Hartley Angle, and the dental profession has derived honor from his genius. He has joined the "elect few." Through the ethereal vapors which enshroud all who have journeyed with Charon across the river Styx into the Great Unknown Beyond we can discern only the heritages left by our benefactors, and, therefore, it is to be hoped that a new and firm bond based upon a fraternal scientific spirit will henceforth prevail.

An analysis of his career and in particular of his early opportunities proves him to have been a genius in the fullest meaning of the word.

> Some bruises, it must be conceded,
> Prepare us for better deeds,
> But the final result of earth's turmoil
> Is one ending alike for us all,
> *Dissolution into the whence of our being*
> *Is the decree of Nature's call.*
>
> —Richard Summa.

NEWS AND NOTES

American Society of Orthodontists

The Thirtieth Annual Meeting of the American Society of Orthodontists will be held on April 21, 22, 23, and 24, 1931, at the Jefferson Hotel, St. Louis, Missouri.

DR. HARRY E. KELSEY, President,
833 Park Avenue,
Baltimore, Md.
DR. CLAUDE R. WOOD, Secretary,
Medical Arts Building,
Knoxville, Tenn.

Second International Orthodontic Congress

The Second International Orthodontic Congress will be held in London in 1931 at the Hotel Great Central from July 20 to 24 inclusive.

The officers of the Congress will be as follows:

President-General	J. H. Badcock
Vice-President-General	G. Northcroft
Treasurer-General	E. D. Barrows
Secretaries-General	A. C. Lockett B. M. Stephens

A list of honorary presidents and vice-presidents will be communicated later.

A full and interesting program of papers and demonstrations is anticipated, and a museum is being organized. Suitable entertainment for ladies accompanying members will be arranged. Intending contributors to the activities of the Congress can obtain from the Secretaries of their respective orthodontic (or dental) societies the conditions under which contributions are invited. The Secretary-General (Mr. A. C. Lockett, 75 Grosvenor Street, London, W. 1) will also be glad to give any further information on request.

Information regarding travelling facilities and hotel accommodation may be obtained from the official agents to the Congress, Messrs. Morgan Pope & Co., of 7 St. James's Street, London, S. W. 1; 6 Rue Caumartin, Paris; 71 Vanderbilt Avenue, New York; Messrs. Noel Vester & Co. (agents), 44 Unter den Linden, Berlin.

Eighth International Dental Congress

The Eighth International Dental Congress is to be held in Paris, August 3-8, 1931.

An important exhibition of dental equipment and supplies will be connected with this Congress and will unite exhibitors from all the countries in the world.

The French Government has placed at our disposal the premises of the Grand Palais des Champs Elysées. In order to be able, already now, to proceed with the repartition of the rooms, we desire to collect as quickly as possible the names of suppliers susceptible of taking part in this exhibition. Consequently, we should be glad if you would inform us whether you intend to participate in this exhibition of the Eighth International Dental Congress and, eventually to indicate what space you would require. Your reply will not constitute an engagement on your part, nor on ours. We request same by way of information, to enable our establishing already now, the spaces which will be required.

The terms will be fixed shortly; we think that the rent, for the duration of the Congress will come to about 500 frs. per square metre.

HENRI VILLAIN,
Commissaire Général des Expositions.

The Dental Society of the State of New York

The sixty-third annual meeting of the Society will be held May 12, 13, 14, and 15, 1931, at Hotel Pennsylvania, New York City.

A cordial invitation is extended to all dentists, members of the American Dental Association, and to all ethical Canadian dentists.

Dr. John T. Hanks, 17 Park Ave., New York City, is Chairman of the Exhibits Committee. Address Dr. Hanks for information relative to space and terms.

Dr. Fred R. Adams, 7 W. Fortieth St., New York City, is Chairman of the Clinic Committee. Under his direction a new plan will be presented in the presentation of the Educational Clinics. Dr. Adams will be pleased to hear from ethical dentists willing to present clinics of merit.

For general information address the Secretary, Dr. A. P. Burkhart.

Dr. Alfred Walker, President,
100 W. 59th St., New York City.
Dr. A. P. Burkhart, Secretary,
57 E. Genesee St., Auburn, N. Y.

New York Society of Orthodontists

The fall meeting of the New York Society of Orthodontists will be held at the Hotel Commodore, Monday, November 24, 1930. This will be an all-day session beginning at 9:30 A.M. An exceptionally interesting program has been arranged. All interested physicians and dentists are cordially invited.

Lowrie J. Porter, Secretary,
730 Fifth Avenue,
New York, N. Y.

A Call to Graduates of the Angle School of Orthodontia

A suggestion has been made by a number of graduates of the Angle School of Orthodontia that we hold a gathering of a social nature at a dinner to be given just preceding the meeting of the American Society of Orthodontists to be held at St. Louis, Mo., in 1931.

The American Society of Orthodontists was organized in St. Louis on June 1, 1900. This is a cogent reason, but only one of the reasons, why we should get together at this time and place. All who favor this idea will kindly and promptly communicate with

Richard Summa,
5552 Etzel Avenue,
St. Louis, Mo.

Notice of Examination for Entrance Into the Regular Corps of the United States Public Health Service

Examination of candidates for commission as assistant dental surgeon in the Regular Corps of the U. S. Public Health Service will be held at Washington, D. C., on November 10, 1930.

Candidates must be twenty-three years and not over thirty-two years of age. They must have been graduated in dentistry at a reputable dental college, and have had a total of seven years of educational training and practical experience. They must undergo a thorough physical examination and must satisfactorily pass oral, written, and clinical tests before a board of officers.

Successful candidates will be recommended for appointment by the President with the advice and consent of the Senate.

Request for information or permission to take this examination should be addressed to the Surgeon General, U. S. Public Health Service, Washington, D. C.

New York University Orthodontic Study Club

The New York University Orthodontic Study Club has been organized with the purpose of furthering knowledge along scientific lines relating to the science of orthodontia.

Membership is limited to the orthodontia faculty and to graduates of the postgraduate course in orthodontics at New York University.

The following officers were elected: Dr. Meyer Hoffman, president; Dr. A. J. Krasny, vice-president; Dr. S. William Singer, secretary-treasurer; and Dr. Samuel Hemley, librarian.

Several interesting problems are being carried on by the members under the guidance and leadership of Dr. Frederick L. Stanton and Dr. Edward M. Griffin.

Greater New York December Meeting for Better Dentistry

The sixth Greater New York December Meeting for Better Dentistry will be held at the Hotel Pennsylvania, New York City, December 1-5, 1930.

As in former years, there will be scientific papers, lecture or teaching clinics, topic discussions, scientific section meetings, and general clinics.

A special feature of this year's meeting will be one full afternoon devoted to the economic side of dentistry. At this session, efficient office conduct will be presented, also valuable information on wise and prudent methods of saving and investments for professional men.

All members of the American Dental Association are eligible to register. Registration fee $5.00.

A subscription blank and list of clinics will be ready for distribution about November 15.

There will be a manufacturers' exhibit in the hotel during the entire meeting.

Chicago Dental Society Midwinter Meeting

The sixty-seventh annual meeting of the Chicago Dental Society will be held at the Stevens Hotel, Chicago, February 2, 3, 4 and 5, 1931.

Because of the great demand last year, the transactions of this meeting will be bound and made available at cost to those who wish them.

The program committee, Dr. Stanley D. Tylman, chairman, has practically finished its work and will present, for the approval of the profession, one of the best programs in the history of the Society.

The exhibition hall of the Stevens Hotel has again been reserved by the Exhibit Committee, of which Dr. C. Davidson is chairman, for manufacturers' and dealers' exhibits and will as always be a center of attraction.

The Society extends a cordial invitation to attend to all members of the American Dental Association.

HARRIS W. MCCLAIN, President,
55 E. Washington St.,
Chicago, Ill.
HOWARD C. MILLER, Secretary,
55 E. Washington St.,
Chicago, Ill.

Notes of Interest

Dr. J. B. Goldsmith announces the removal of his office to 110 Central Ave., at Lord Avenue, Lawrence, L. I., New York; New York office at 200 West Fifty-Ninth Street. Practice limited to orthodontia exclusively.

Dr. Louis Braun announces completion of studies at the Dewey School of Orthodontia and the opening of new offices at Suite 1806, Eaton Tower, Detroit, Mich.

Dr. L. H. Hughes wishes to announce that he has limited his work to the practice of orthodontia exclusively.

Dr. Oscar Jacobson announces his new address is 473 West End Avenue, New York City. Practice limited to orthodontia.

Dr. Raymond L. Webster announces the association of Dr. Donald D. Osborn in the practice of orthodontia, 155 Angell Street, Providence, R. I.

Dr. Howard B. Gates wishes to announce the opening of his office for the practice of dentistry, orthodontia a specialty, Room 515, Utica Gas and Electric Building, Utica, New York.

Dr. Frank F. Lamons announces the removal of his offices to Suite 728 Candler Building, Atlanta, Ga. Practice limited to orthodontia and children's dentistry.

Dr. Edward R. Coleman, formerly associated with the late Dr. Samuel P. Cameron in the practice of orthodontia, announces his succession to the practice, 1836 Delancey Street, Philadelphia, Pa.

Dr. C. Franklin MacDonald announces the removal of his office to 20 East Fifty-Seventh Street, New York, N. Y.